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JOINT WHO/FAO/UNEP PANEL OF EXPERTS
ON ENVIRONMENTAL MANAGEMENT FOR VECTOR CONTROL

GUIDELINES FOR FORECASTING THE VECTOR-BORNE DISEASE IMPLICATIONS IN THE DEVELOPMENT OF A WATER RESOURCE PROJECT

PRELIMINARY DRAFT VERSION

Geneva, May 1987

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GUIDELINES FOR FORECASTING THE VECTOR-BORNE DISEASE IMPLICATIONS IN THE DEVELOPMENT OF A WATER RESOURCES PROJECT

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PREFACE TO THE PRELIMINARY DRAFT VERSION

In many parts of the world water resource development, irrigation expansion, dam construction, are likely to have adverse effects on human health, unless proper measures are incorporated from the early planning and design stage onwards. In order to be able to decide which measures should be incorporated where in the design, and implemented at what stage of the construction, a first requirement is a fairly reliable assessment of the health risks involved in the project.

Ideally, such an assessment could perhaps best be carried out by a group of health specialists, comprising epidemiologists, parasitologists and entomologists, who might collect valuable baseline data in longitudinal surveys, and study the effects of water resource development in comparable areas where this has already taken place. However, in reality two factors are usually lacking: time and funds. In many parts of the world water resource development, for instance to increase food production, is a matter of great urgency. And the current economic situation is not favourable for the implementation of costly health surveys at the feasibility stage of each water resource development project.

These and other aspects were discussed during the technical discussion at the third meeting of the joint WHO/FAO/UNEP Panel of Experts on Environmental Management for Vector Control (PEEM), on "Methods of forecasting the vector-borne disease implications in the development of the different types of water resources projects" (Rome, 12-16 September 1983). At the end of this meeting the Panel recommended the preparation of guidelines for the forecasting exercise, which should take the outcome of its discussions as their starting point.

The task of preparing the guidelines was accepted by Dr Martin Birley, entomologist at the Liverpool School of Tropical Medicine. His initial draft followed the matrix-approach indicated by the Panel. However, this was soon found to be too static, and a more dynamic process of flowcharts was developed. These were complemented by a set of rules-of-thumb, in the typical if-then structure which could form the basis for the further development of an expert system for forecasting.

Several other drafts followed; the present document has benefitted from comments and suggestions from within the three organizations, and even a special meeting was held in January 1986 in Zurich to refine it and make it compatible with other guidelines under preparation. It was then decided to give the preliminary draft version a limited circulation to receive comments from people in the field (and in particular from engineers, who are the major target group), before finalizing it and preparing the definitive version for official publication.

In order to assist in the review of the guidelines, and the subsequent revision of the draft, the following questionnaire asks for the reader's assessment of specific sections and of the more general characteristics of the document. Additional comments are invited on any issues considered relevant by the reviewer, but not covered by the questionnaire.

For a timely collection and analysis of the feed-back it is appreciated if the questionnaire, duly filled in, is returned to the PEEM secretariat, WHO, Geneva, Switzerland, no later than four weeks after receipt of this document.

QUESTIONNAIRE

Reviewers background. Before anwering to the following questions, please provide brief details about (1) your professional background and experience, (2) your academic qualifications and (3) your present function. This will enable us to correlate the opinions of the reviewers to their background and involvement with health and/or water resource development.

(1)

(2)

(3)

Introduction and chapter 1

1. Do introductory paragraphs 1.1 to 1.6 provide adequate:
   - background yes ☐ no ☐
   - purpose yes ☐ no ☐

2. Does the scoring system in paragraph 1.7 provide :
   - an acceptable means of assessing components yes ☐ no ☐
   - a practical approach towards assessing the total vector-borne disease hazard yes ☐ no ☐

3. Is the forecasting exercise described in paragraphs 1.8 to 1.10 and in the subsequent flowcharts and text:
   - adequately presented yes ☐ no ☐
   - logical yes ☐ no ☐
   - in a correct sequence yes ☐ no ☐
   - practical for application yes ☐ no ☐

If one or more of the above questions were answered negatively, please elaborate on suggested changes and improvements (use separate sheet if necessary):

Chapter 2

4. With the non-medical readership in view in particular, is the information in chapter 2 adequate in terms of:

- disease distribution yes ☐ no ☐
- vector habitat description yes ☐ no ☐
- disease transmission patterns yes ☐ no ☐
- vector characteristics yes ☐ no ☐
- vector control methods yes ☐ no ☐
- intervention strategies yes ☐ no ☐
- monitoring and evaluation yes ☐ no ☐

If one or more of the above questions were answered negatively, please elaborate on suggested changes and improvements (use separate sheet if necessary):

Chapter 3

5. Does chapter 3 present the rules-of-thumb concept adequately for application yes ☐ no ☐

6. Are there
additional factors to be incorporated in the listing yes ☐ no ☐

rules-of-thumb you may want to propose on the basis of your own experience yes ☐ no ☐

If so, please state below (use separate sheet if necessary):

Appendices

7. Appendix 2 presents a provisional checklist for completion of the flowcharts. Considering the probable non-medical background of the user, are the questions:

- correctly targetted to obtain the required info — yes ☐ no ☐
- correctly framed to obtain the required info — yes ☐ no ☐
- sufficiently comprehensive to obtain the required info — yes ☐ no ☐

If one or more of the above questions were answered negatively, please elaborate on suggested changes or improvements (use separate sheet if necessary):

The guidelines as a whole

8. The overall guidelines are intended to combine an in-breadth and an in-depth approach to the assessment of vector-borne disease risks in water resource development. In principle, do you consider this approach

suitably balanced in breadth and in depth		yes	☐	no	☐
if not, should the guidelines go	in depth:	more	☐	less	☐
	in breadth:	more	☐	less	☐
adequate in its sequence and structure		yes	☐	no	☐
straightforward for application		yes	☐	no	☐

9. The content of the guidelines consists largely of tables and matrices which are distributed throughout the text. Do you consider that the accessibility of this material is

- adequate as at present — yes ☐ no ☐
- better assembled after each chapter — yes ☐ no ☐
- better assembled as a separate annex — yes ☐ no ☐

After filling in this questionnaire, please take the entire section out of the document and return it to the PEEM secretariat, World Health Organization, Geneva, Switzerland.

PREFACE

"I fully realize that health is not the only thing, but that everything else, without health, is nothing, and I think that it is very important to realize this when we look at development at large. Whenever the health component is forgotten, you forget at the same time the vital factor in development, namely the human being, his creative energy, his physical energy."

Dr H. Mahler
Director-General WHO (1982)

An increase in the prevalence of vector-borne diseases of parasitic, bacterial or viral origin is a common adjunct of water resource development in the tropics. Well known examples include the Aswan, Kariba and Volta Lake dams which were constructed to provide economic benefits such as irrigation or hydro-electric power, but which also bestowed additional malaria, schistosomiasis and other health burdens on the local community. During a malaria epidemic in the Gezira scheme (Sudan) 33 working days were lost per tenant, reducing cotton production by an estimated 20%. On the same scheme the prevalence of schistosomiasis has now reached 70%. The development of water resources seems bound to continue, for how else can the quality of life of the majority of the world population be improved? However, a concomitant rise in disease prevalence could significantly reduce the expected benefits. Two requirements must be fulfilled if such an increase is to be prevented. The first requirement is a strong and binding commitment by governments and international aid agencies "...not to help finance any project that seriously compromises public health or safety, causes severe or irreversible environmental deterioration, or displaces people without adequate provision for resettlement..." (World Bank, 1984). The second requirement is a rapid, simple and cheap procedure for determining whether, and how, the first requirement can be fulfilled.

Water resource development projects are usually planned by economists, agriculturalists and engineers and these are the intended readers of this document. The objectives are as follows: to inform planners of the vector-borne disease situation which may exist at the project site; to pinpoint those features of the environment which enhance or reduce the risk of disease transmission; to suggest disease management practices which exist or could be introduced for controlling the diseases; and, most important of all, to consider how the risk of vector-borne disease could be reduced by incorporating environmental management measures into the project design or operation.

After a realistic appraisal of environmental health hazards has been obtained, the planner can consider the cost of mitigation and how it may be financed.

Although human health has to be considered as a whole, especially the total relation of water to health, the scope of this document is limited to a consideration of vector-borne diseases. The term "vector" is used in its broadest sense to include both true vectors (biting insects) and intermediate hosts (snail hosts of schistosomiasis) and animal reservoirs of disease (such as rodents). However, the only vectors considered are those whose breeding sites may be disturbed by water resource development projects.

The forecasting procedure can only be applied to its full potential if links are established, from the very start, with the various departments and government ministries which are concerned with health.

CHAPTER 1. THE GUIDELINES.

1.1. Who should use these guidelines?

This is a workbook for anyone who wishes to make a rapid assessment of the health risks associated with a water resource development project in the tropics or sub-tropics. It poses a minimum number of questions in a format which enables reasonably accurate answers to be obtained without field surveys. It is assumed that you can establish links with key personnel within the local ministry of health, who will have informed answers to some or all of the questions which you are going to ask them. It is also assumed that you are carrying out this assessment because you wish to design safeguards or plan mitigation measures.

1.2. How to use these guidelines

To make a forecast, read (You will be referred to the other chapters as you need them).	Chapter 1.
To learn about vector-borne diseases, read	Chapter 2.
To learn "the rules", read	Chapter 3.
To check the glossary, see	Chapter 4.

1.3. Scope

The four categories of diseases which are associated with water are indicated in figure 1.1. Two of these categories are often adversely affected by water resource development projects. Careful planning of structures and operating schedules, referred to as environmental health engineering and environmental management, can help to prevent or reduce transmission of some of these diseases.

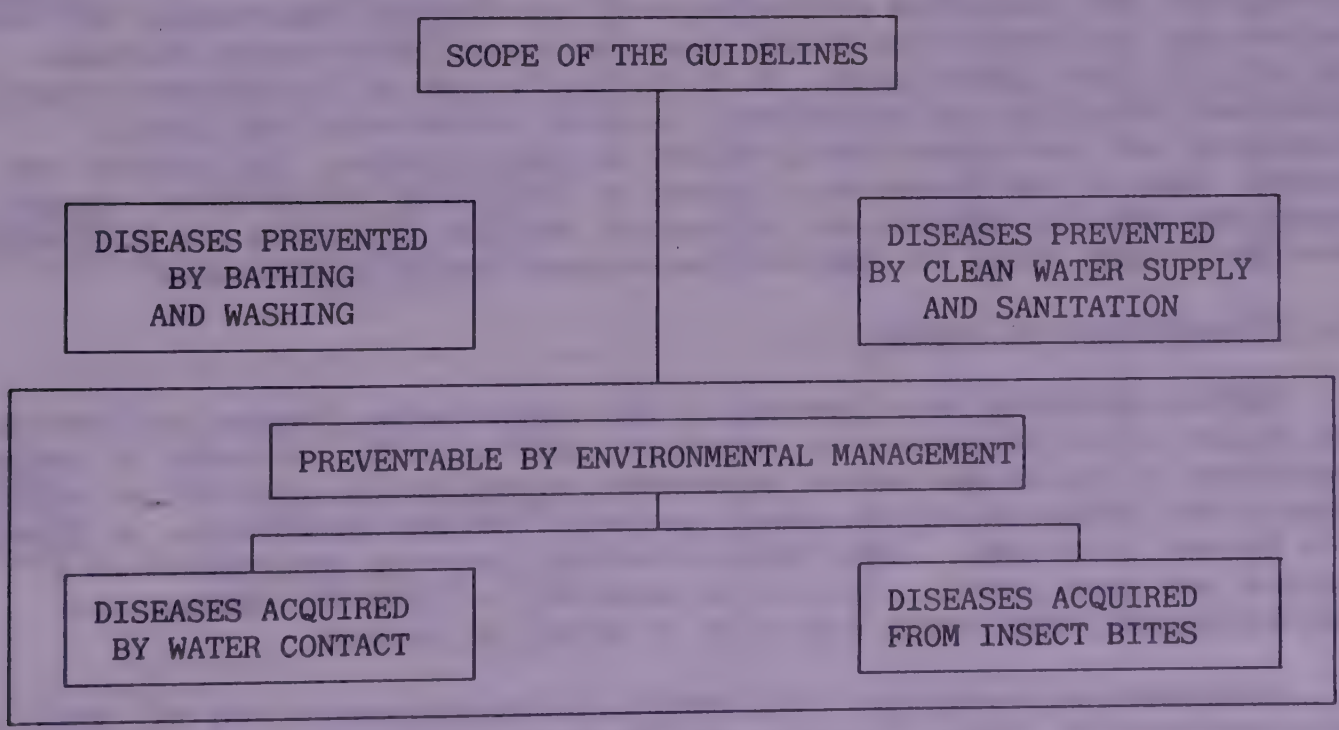


Figure 1.1. The scope of the guidelines.

Bloodsucking insects acquire pathogenic organisms by biting infected people or, in some cases, infected animals. Transmission may occur when they subsequently bite healthy individuals. Water contact diseases depend on intermediate hosts such as snails. Transmission may occur when people have contact with infected water which contains the intermediate host. The term "vector" will mainly be used in this document in the sense defined in the accompanying inset. This definition will sometimes be expanded to include animal reservoirs.

DISEASE VECTORS	=	BITING INSECTS	or	INTERMEDIATE HOSTS

Eradication of vectors is usually impossible. However, our objective is to reduce or eliminate the transmission of disease by the vector, not the vector itself. In order to achieve this objective the number of vectors, or degree of man/vector/pathogen contact must be reduced. The degree of vector or water contact required to produce clinical disease varies widely. Therefore, the degree of vector suppression to be achieved depends on the epidemiology of the disease, the local environment and the human population.

1.4. Forecasting objective

The objective of the forecasting procedure is to complete worksheet 1, (see page 9), which indicates whether the hazard associated with each vector-borne disease is likely to be reduced, to remain the same or to be increased at each project phase. Although desirable, a more detailed forecast would require a much larger investment in time and other resources. However, this worksheet and the reasoning behind it should provide a sufficient basis for comprehending health hazards.

1.5. Forecasting procedure

Figure 1.2 (page 10) is an overview of the forecasting procedure. First, individuals are identified within regional and district departments and research centres who are prepared to answer questions about vector-borne diseases. With the help of these individuals, an inventory is made of the disease situation, management practices and environment in which transmission may occur. Flowcharts and worksheets are provided for this purpose. The results are scored. Much of the procedure is aimed at justifying the assigned scores. A report may then be prepared and mitigation measures discussed and followed-up. When the project phase is complete the outcome should be evaluated.

1.6. The ministry of health

Before embarking on a forecast of the vector-borne disease implications of the project it is imperative to establish links with the ministry of health. Ministries of health are central government organisations controlling policy, finance and statistics of the health sector. They may stand alone or form part of a larger structure. They usually contain numerous departments at a national and local level. It will be necessary to identify appropriate individuals and departments with whom to establish contact.

Management of a ministry of health is the responsibility of political and administrative heads (Minister and Permanent Secretary) and a technical head, the Director of Medical Services. The technical branches will be headed by Deputy Directors of Medical Services (DDMS). These branches will

WORKSHEET 1. SUMMARY FORECAST.

PROJECT TITLE ______________________________________

TYPE ______________________________________

LOCATION ______________________________________

DATE OF FORECAST ______________

PROJECT PHASE: PRE-PROJECT ☐ CONSTRUCTION ☐ OPERATION ☐

	DISEASE: Specific type:	MALARIA ________	SCHISTO-SOMIASIS ________	________ ________
A DISEASE SITUATION	NONE LOW MEDIUM HIGH	☐ ☐ ☐ ☐	☐ ☐ ☐ ☐	☐ ☐ ☐ ☐
B TRANSMISSION POTENTIAL	NONE LOW MEDIUM HIGH	☐ ☐ ☐ ☐	☐ ☐ ☐ ☐	☐ ☐ ☐ ☐
C MANAGEMENT EFFECTIVENESS	CONTROL+TREATMENT CONTROL ONLY TREATMENT ONLY NEITHER	☐ ☐ ☐ ☐	☐ ☐ ☐ ☐	☐ ☐ ☐ ☐
TOTAL HEALTH HAZARD	REDUCED OR LOW SAME OR MODERATE INCREASED OR HIGH	☐ ☐ ☐	☐ ☐ ☐	☐ ☐ ☐

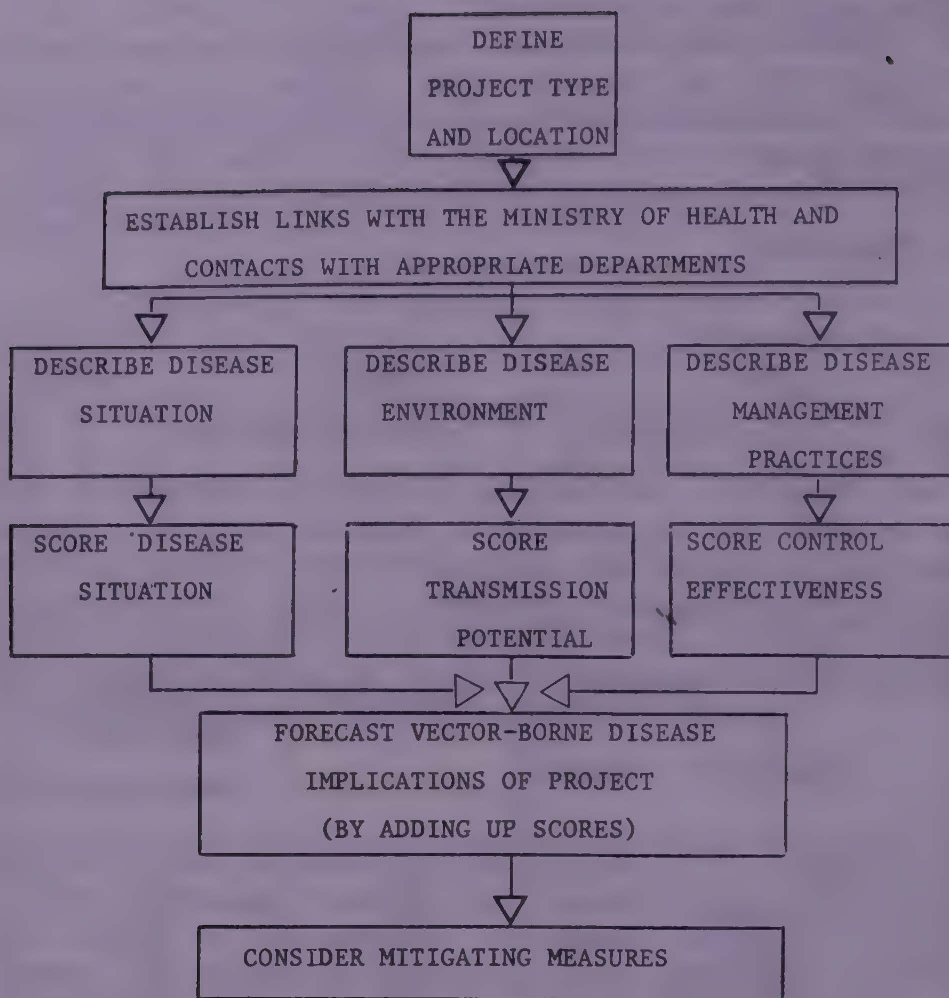


Figure 1.2. Logical steps required for forecasting vector-borne disease implications of water resource development projects.

have responsibility for epidemiology, public health and environmental control. A traditional example of the structure of the health sector is that in which the officer in charge controls one aspect of central government policy and supervises regional, district and local medical and health staff. He or she will have information on government run project centres, relevant research bodies and local government health organisations. However, in countries with a functional primary health care system, responsibility has, to a large extent, been deferred to district level, and it will also be at that level that information has to be collected.

Enquiries should begin at DDMS level to obtain national data and the addresses of project and research centres which should be approached subsequently. Next, the relevant district health centres can be approached directly. Further details of the necessary institutional arrangements are discussed in the guidelines for the incorporation of environmental management and other health safeguards in water resource development projects, which at the time of publication of this preliminary version are still under preparation.

1.7. Scoring system

A descriptive score is assigned to each component. The three component scores are weighed according to their relative importance and a score is assigned to the final forecast which is supported by a descriptive summary.

A. The disease situation provides a measure of disease prevalence in the vicinity of the project site. This is the situation which may be changed by the project related activities.

Very low or remote risk.

Low risk. For example: the parasite is present but not within 50 km of the project site or 100 km downstream on the same watercourse; the disease is present within 500 km and is resistant to drug treatment or the vector is resistant to commonly available pesticides; the disease is likely to be introduced by immigrants.

Medium risk. The disease is present in restricted foci at or near the project site, or there are relatively few susceptible people. Immigrant settlers or workers would be the main groups at risk.

High risk. The population are largely susceptible to infection, there is little protective immunity or little experience of the disease. The parasite is likely to be introduced.

B. The disease transmission potential, or disease environment, describes the vector species which are present and their habitat. It indicates whether parasite transmission is possible.

No means of parasite transmission.

Parasite transmission potential is low or has been reduced by project operations.

Parasite transmission potential is moderate or unaffected by the project.

Parasite transmission potential is high or increasing.

C. The disease management effectiveness, or disease management practices, describes the health and pest control services which are or will be available at and near the project site.

Very good health services which include effective preventive measures (such as vector control and chemoprophylaxis) and effective treatment (including personnel, access, case detection and drug supply).

Effective preventive measures only.

Effective treatment only.

No effective health services of any kind either because there is no infrastructure or because the available health services are over-stretched, under-supplied or inaccessible.

1.8. Describing the disease situation, environment and management

Worksheet 2 (appendix 1, see page 93) contains a summary description of the project and provides the basis for assigning the scores in worksheet 1. Therefore, worksheet 2 must be partially or wholly completed before completing worksheet 1. However, worksheet 2 is a list of questions with no indication of why each question is important or how it should be answered.

By contrast, the flowcharts which follow, order the enquiry into a logical structure, indicating why each question is relevant and how the answer should be obtained.

Example 1 on the next page indicates how worksheet 1 might have been completed for the construction phase of an irrigation scheme somewhere in Africa. The summary could be interpreted as follows.

a. Falciparum malaria is expected to represent a health hazard during the construction phase because susceptible people will be exposed to the vector and no preventative measures are planned. A large percentage of the workforce may be incapacitated.

b. Schistosoma mansoni does not occur near the project site but a potential vector is present. This disease requires a high contact frequency. The health hazard is low during the construction phase but will increase during the operational phase unless potentially infective immigrants or construction workers and their families are screened on arrival or other preventative measures are instigated.

c. Onchocerciasis occurs in the region but there is no vector at the project site. However, breeding sites are being created by the project and the vector is capable of long-distance migration. Therefore, the health hazard could increase during the operational phase.

Such a summary forecast is insufficient in itself. Each conclusion must be justified by reference to the answers listed in worksheet 2 which, in turn, depend on the flowchart.

1.9. Flowchart organisation

The flowcharts assume a demand-pull process of interrogation. The user asks particular questions of the health specialist rather than the health specialist advising the user about what he/she considers important. The questions are directed at different health specialists within the ministry of health or its equivalent. Checklist 1 (appendix 2, page 98) orders the same questions into groups according to whom they will be addressed. This will enable the user to plan his interviews.

The flowcharts are organised in a backwards chaining structure. Each chart starts with the conclusion and presents the facts required to justify that conclusion. This process informs the user why each question is relevant.

The flowcharts are organised on a series of deeper levels (see figure 1.3., page 15). Each level is a subsidiary conclusion. The user may choose either a depth first or a breadth first completion procedure.

A breadth first procedure will satisfy the user who either has a limited amount of time or other resources to devote to the forecast, or wishes to obtain an overview of the problem. This user will guess the answers to subsidiary questions and use the guesses to justify his conclusions. Such a procedure is reasonable provided that the guesses are clearly indicated as such in work-sheet 2. Then readers of the final report can judge for themselves the conclusions and the guesses from which they arise.

WORKSHEET 1. SUMMARY FORECAST.

PROJECT TITLE ______________________________

TYPE ______________________________

LOCATION ______________________________

DATE OF FORECAST ______________

PROJECT PHASE: PRE-PROJECT [ ] CONSTRUCTION [X] OPERATION [ ]

	DISEASE:	MALARIA	SCHISTO-SOMIASIS	Filariasis
	Specific type:	falciparum	mansoni	onchocerciasis
A DISEASE SITUATION	NONE			
	LOW		X	X
	MEDIUM			
	HIGH	X		
B TRANSMISSION POTENTIAL	NONE			X
	LOW			
	MEDIUM	X	X	
	HIGH			
C MANAGEMENT EFFECTIVENESS	CONTROL+TREATMENT			
	CONTROL ONLY			
	TREATMENT ONLY	X		
	NEITHER		X	X
TOTAL HEALTH HAZARD	REDUCED OR LOW		X	X
	SAME OR MODERATE			
	INCREASED OR HIGH	X		

A depth first procedure will satisfy the user who has more time and resources to devote to the task. Each question raises subsiduary questions at deeper levels which must be answered before a conclusion is derived. The deeper the level reached, the more confidence can be attached to the conclusion.

It must be emphasised that even if all the questions are answered on all levels the procedure would only begin to approach the norm of a rigorous scientific enquiry.

SUMMARY

1. Worksheet 1 contains a summary of the final forecast.

2. The flowcharts lists questions which which should be answered in the order indicated. The questions may be answered by one of 4 different methods, as appropriate.

* Refer to chapters 2 and 3.
* Ask a specialist.
* Make an informed guess.
* Use your previous knowledge and experience.

3. Worksheet 2 lists the questions in the same order as the flowchart and provides a space for each answer. Copies of worksheet 2 will be required for each disease in each project phase.

4. Checklist 1 reorders the same questions so that they may be completed after a single interview with a specialist who has access to the appropriate information.

1.10. THE FLOWCHARTS

The following flowcharts order the information required for making the forecast. Each flowchart occupies one page and is accompanied by a short discussion.

The questions on the flowcharts must be answered for **each disease and each project phase**.

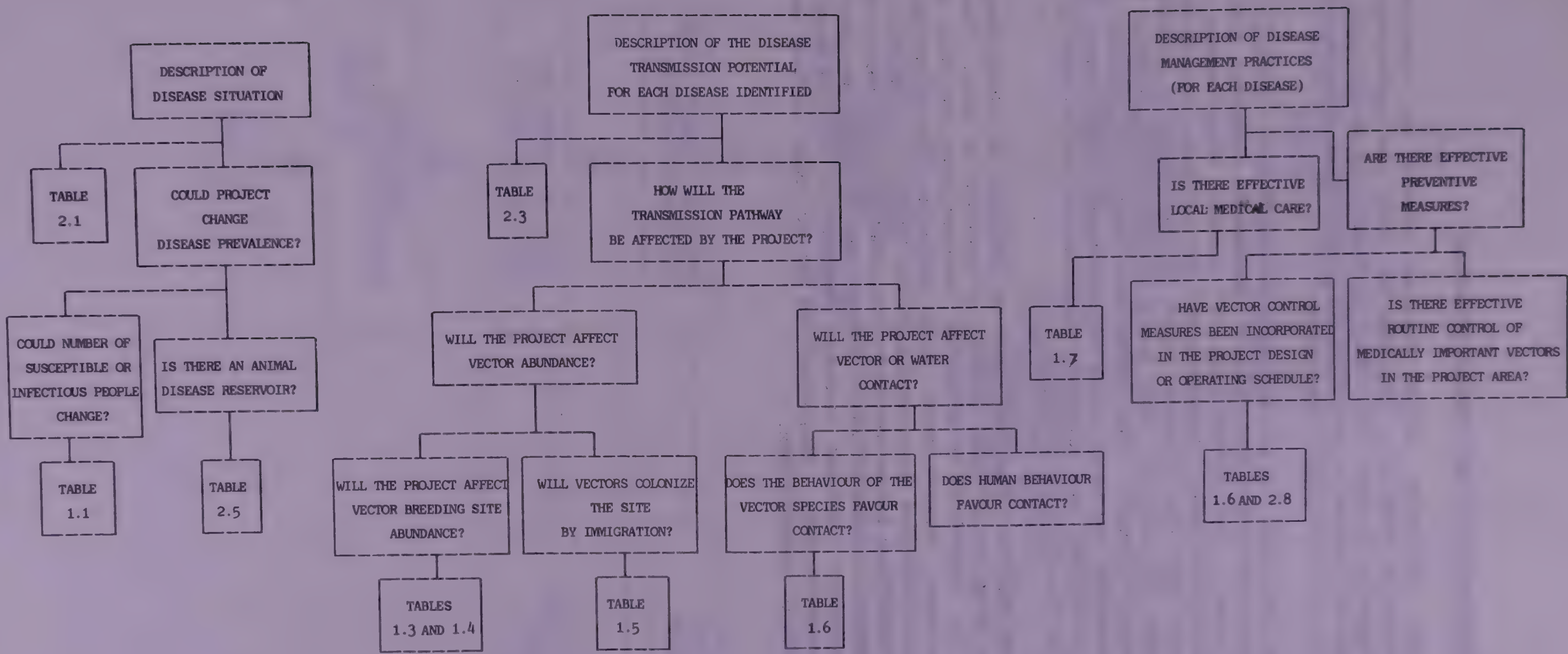


Figure 1.3 The root structure of the flowcharts.

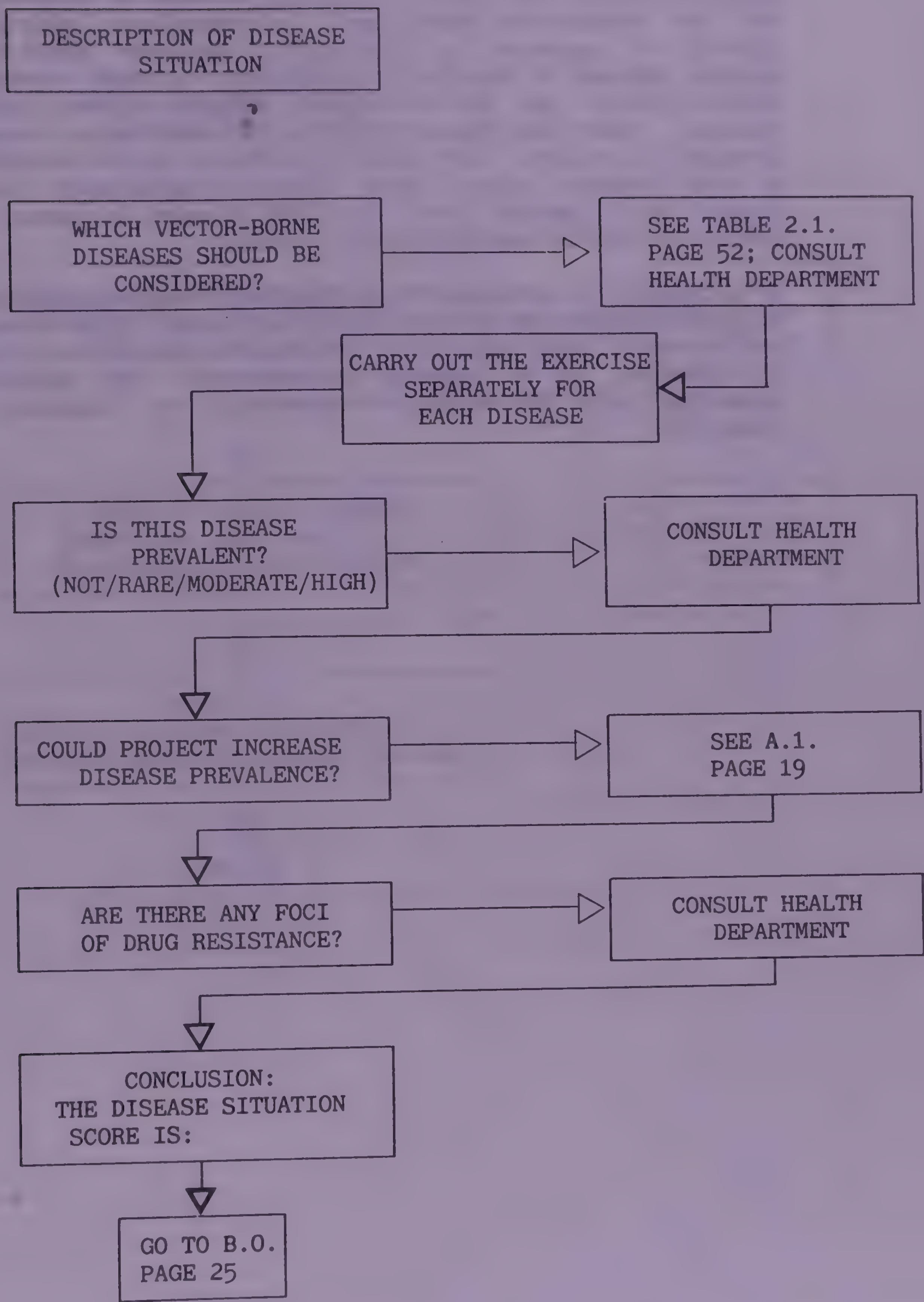
A.0. DESCRIPTION OF THE DISEASE SITUATION

First determine which diseases should be considered by reviewing table 2.1. (see page 52) and the accompanying maps (appendix 3, page 100). There is always the possibility that an unusual disease is prevalent in a particular location, so check this with the health department.

For this part of the analysis we assume that there is disease transmission and that disease management practices will not be altered. The future risk of disease then depends on the susceptible human community and the parasite reservoir. What risk does the disease score (on the rating in section 1.7., pages 10 and 11) and how will that risk be altered by the project phase? The acceptable level of disease in the community, the level which is considered 'significant', depends on political and cultural boundaries and advice must be sought from the ministry of health.

Some important diseases, such as malaria, no longer respond to the drugs which used to offer protection or cure. Therefore, it is imperative to determine whether there are foci of drug resistant disease which could undermine the effectiveness of health services associated with the project. Similarly, many vectors have become resistant to commonly used insecticides and chemical methods of vector control may no longer be appropriate. Resistance develops rapidly compared to the life-span of the average project. Many countries can no longer afford the high price of insecticides.

A.O.

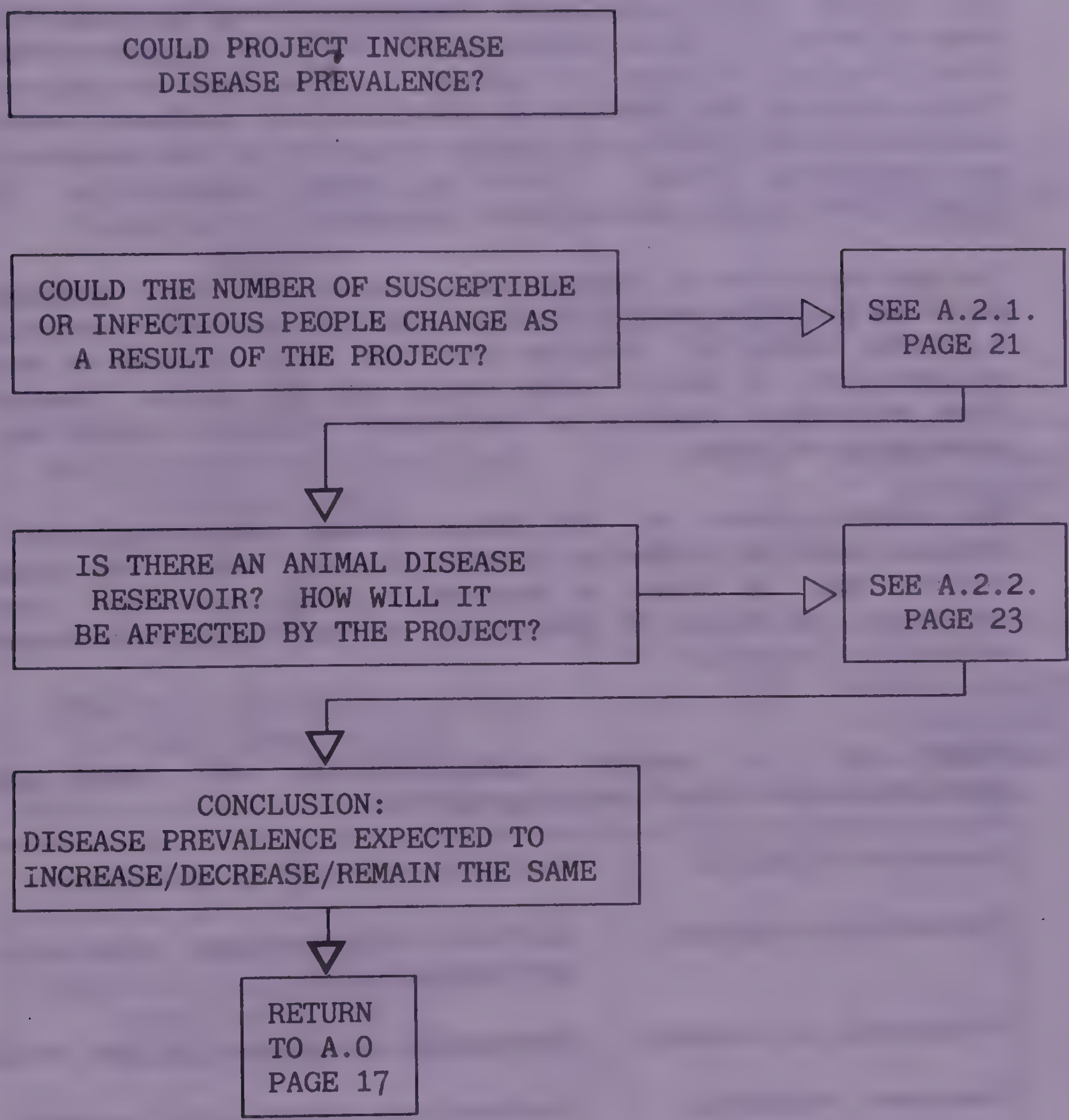

DESCRIPTION OF DISEASE SITUATION
WHICH VECTOR-BORNE DISEASES SHOULD BE CONSIDERED?
SEE TABLE 2.1. PAGE 52; CONSULT HEALTH DEPARTMENT
CARRY OUT THE EXERCISE SEPARATELY FOR EACH DISEASE
IS THIS DISEASE PREVALENT? (NOT/RARE/MODERATE/HIGH)
CONSULT HEALTH DEPARTMENT
COULD PROJECT INCREASE DISEASE PREVALENCE?
SEE A.1. PAGE 19
ARE THERE ANY FOCI OF DRUG RESISTANCE?
CONSULT HEALTH DEPARTMENT
CONCLUSION: THE DISEASE SITUATION SCORE IS:
GO TO B.O. PAGE 25

FLOWCHART A.1.

Transmission of vector-borne diseases depends on the conjunction of three separate elements: the parasite (in an infective host), the vector (providing a means of transmission) and the susceptible human host. In communities with a long history of exposure to a specific parasite there will be varying degrees of immunity to infection. In such communities susceptibility may be restricted largely to young children. However, water development projects can cause major changes in community structure. For example, settlers may be brought from a high mountain area, where malaria transmission does not occur, to a lowland area where the disease is common. Such settlers would be susceptible as a group.

If a disease is prevalent then there are both susceptible and infective people and a means of transmission. If a disease is not prevalent there may be: no susceptible people; or no source of infection; or no means of transmission. The transmission potential will be evaluated separately in flowchart B.0. (page 25).

A.1.


COULD PROJECT INCREASE DISEASE PREVALENCE?
COULD THE NUMBER OF SUSCEPTIBLE OR INFECTIOUS PEOPLE CHANGE AS A RESULT OF THE PROJECT?
SEE A.2.1. PAGE 21
IS THERE AN ANIMAL DISEASE RESERVOIR? HOW WILL IT BE AFFECTED BY THE PROJECT?
SEE A.2.2. PAGE 23
CONCLUSION:
DISEASE PREVALENCE EXPECTED TO INCREASE/DECREASE/REMAIN THE SAME
RETURN TO A.0 PAGE 17

FLOWCHART A.2.1.

In order to determine how the human community will be affected by the project it is necessary to classify the groups making up the community and to consider the health status of each group.

The groups associated with the project may be classified in several ways. It may be appropriate to group together families from the same village or region. It may also be appropriate to distinguish the families of construction workers, settlers, spontaneous immigrants and prior occupants of the proposed site and peripheral sites. Table 1.1. below suggests a simple classification for resettlement schemes.

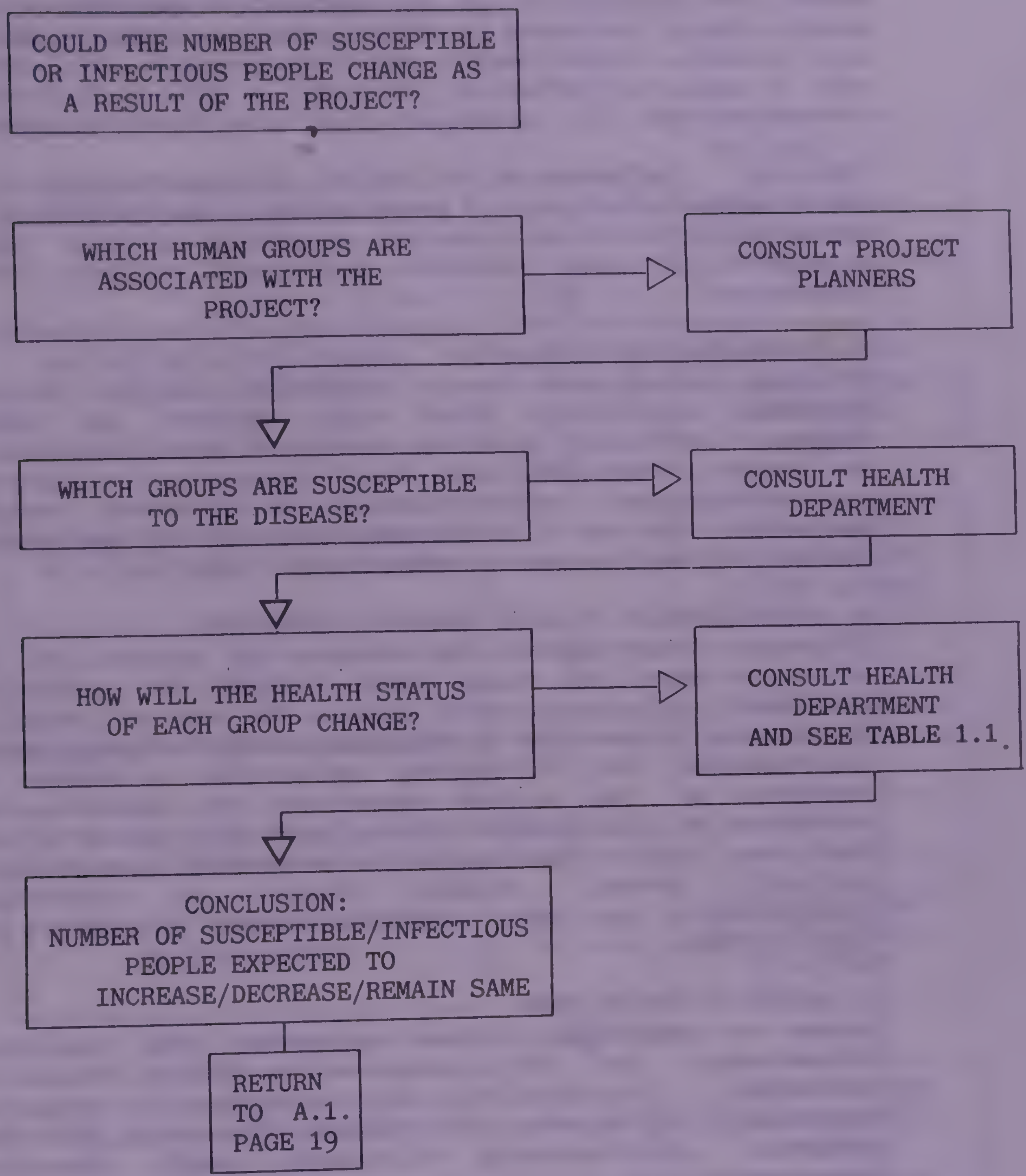
The age structure of communities associated with development projects is often very different from the national norm because a greater number of children are born and survive or because settlers are in their prime child bearing years. Immigrants from different regions or different climatic zones may be especially at risk.

The health status of the human groups associated with the project could be affected in many complex ways. For example, settlers may be close to starvation until the first crop is harvested. A number of indicators of well-being are listed in table 1.2. (page 22).

TABLE 1.1. **A simple classification of human groups associated with resettlement projects.**

Scheduled migrants	=	Settlers selected by government.
Unscheduled migrants	=	Self-selected settlers, squatters and encroachers.
Relocatees or evacuees	=	Communities displaced by the project.
Temporary residents	=	Construction workers and seasonal farm labourers.

A.2.1.


COULD THE NUMBER OF SUSCEPTIBLE OR INFECTIOUS PEOPLE CHANGE AS A RESULT OF THE PROJECT?
WHICH HUMAN GROUPS ARE ASSOCIATED WITH THE PROJECT?
CONSULT PROJECT PLANNERS
WHICH GROUPS ARE SUSCEPTIBLE TO THE DISEASE?
CONSULT HEALTH DEPARTMENT
HOW WILL THE HEALTH STATUS OF EACH GROUP CHANGE?
CONSULT HEALTH DEPARTMENT AND SEE TABLE 1.1
CONCLUSION:
NUMBER OF SUSCEPTIBLE/INFECTIOUS PEOPLE EXPECTED TO INCREASE/DECREASE/REMAIN SAME
RETURN TO A.1. PAGE 19

FLOWCHART A.2.2.

Diseases which have an animal reservoir are listed in table 2.5, (page 55) together with the associated animal group. There is always the possibility of an unknown or rare arbovirus or parasite being harboured by wild rodents or birds. A project which disturbs a rural habitat could bring people into contact with a source of infection. Problems of this kind are often encountered when new tracts of land are first cultivated.

TABLE 1.2. **Indicators of well-being, a classification of the health related attributes of human groups.** See guidelines for the incorporation of environmental management and other health safeguards in water resource development projects (under preparation).

1. SOCIO-CULTURAL INDICATORS
Literacy, educational levels, economic levels, housing standards (construction, piped water), personal and public hygiene, traditional practices considered beneficial/harmful to health, access to and use of clean water (standpipes, protected sources), excreta disposal. Use of bednets, screens and sprays. Purchase of modern medicines and self-medication. Tendency to seek access to modern health care.

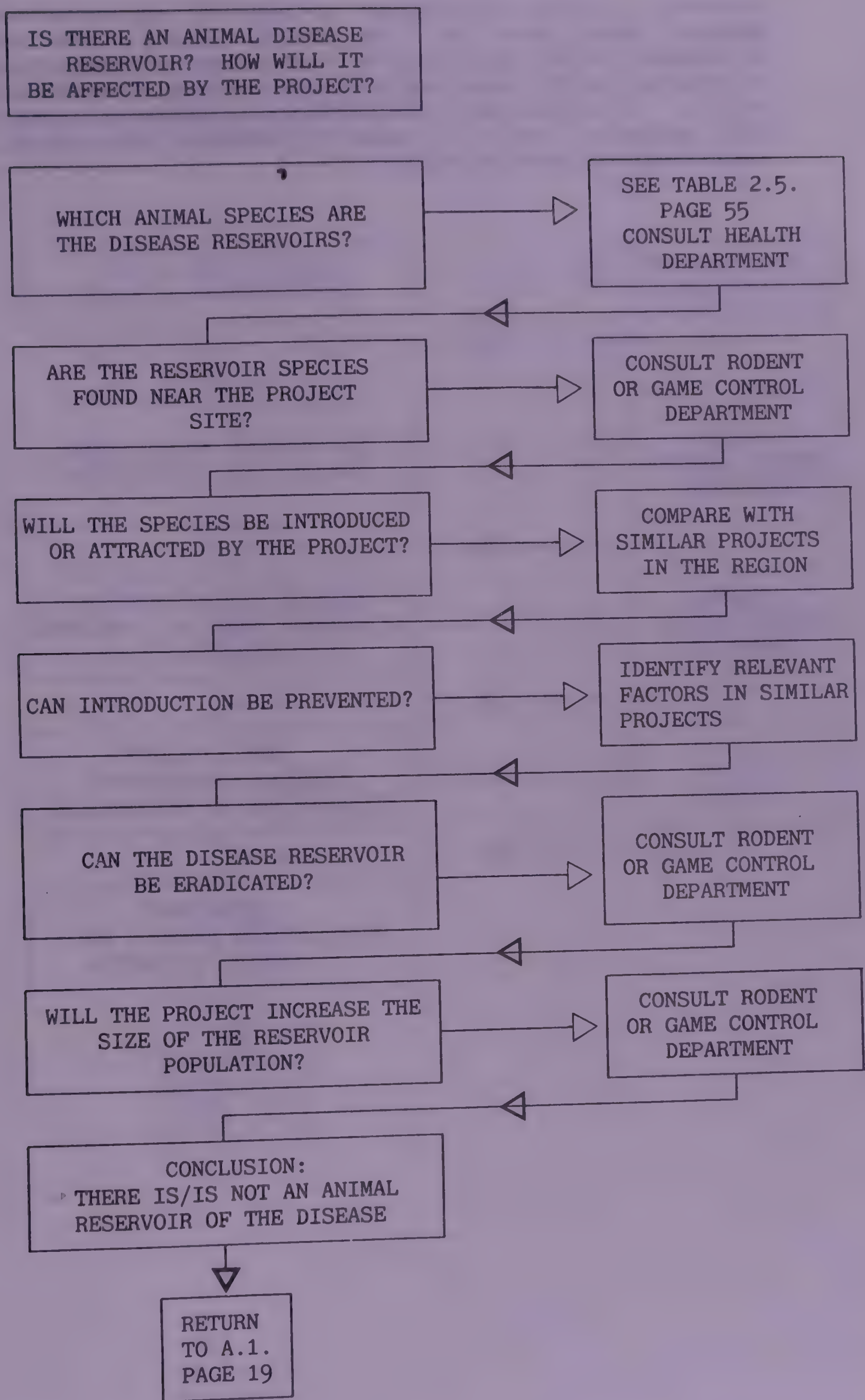
2. PRIOR EXPOSURE TO EACH PARASITIC INFECTION
Of primary importance is the presence or absence of the infection among the human groups forming the community. Additional information would include the acquired immunity, tolerance or premunition to the parasite strains encountered; the potential for introducing new species or strains of parasites to the project community; the intensity and prevalence of infection;the rates of morbidity and mortality. Each group may be characterised as non-immune (susceptible), partially immune, totally immune or infectious. Susceptibility may vary seasonally because of sickness and food shortage.

3. ACCESS TO HEALTH CARE
Access to physicians, nurses and nurses' aids, hospitals, dispensaries and aid posts within walking distance or otherwise. Distribution of prophylactic medicines (especially for malaria), distribution of curative medicines (malaria, schistosomiasis, filariasis), health education, immunization rate.

4. GENERAL HEALTH INDICATORS
Gastro-intestinal and respiratory infections, nutrition, indices of other parasitic infections, accidents, infant mortality, expectation of life.

5. PRIOR KNOWLEDGE OF EACH DISEASE
Where there is no significant protective immunity to a parasitic infection a human group may still cope better with exposure to infection because of prior experience, or folk knowledge. The knowledge may reduce distress and fear and may motivate behaviour which limits exposure to infection or may promote indifference.

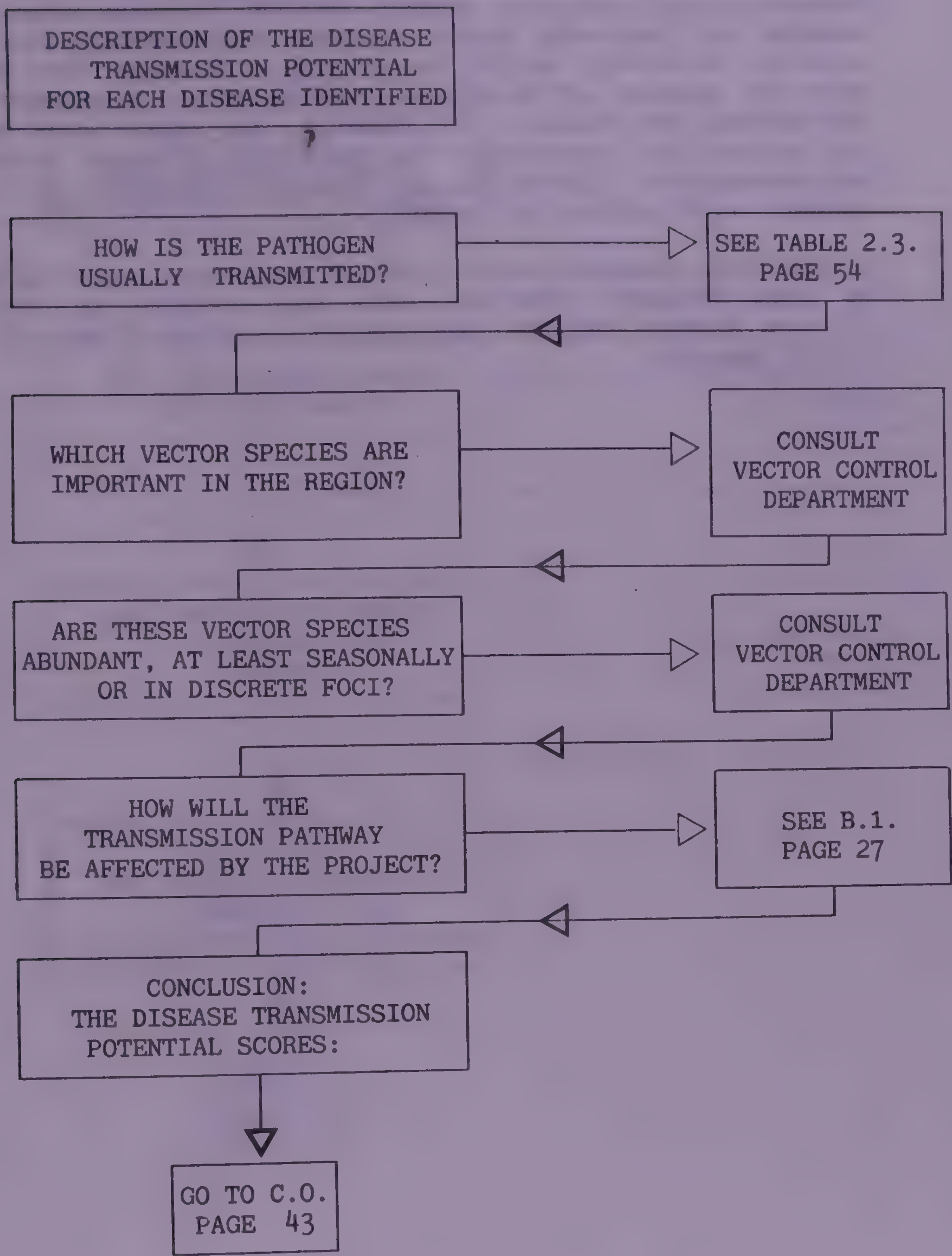
A.2.2.


IS THERE AN ANIMAL DISEASE RESERVOIR? HOW WILL IT BE AFFECTED BY THE PROJECT?
WHICH ANIMAL SPECIES ARE THE DISEASE RESERVOIRS?
SEE TABLE 2.5. PAGE 55 CONSULT HEALTH DEPARTMENT
ARE THE RESERVOIR SPECIES FOUND NEAR THE PROJECT SITE?
CONSULT RODENT OR GAME CONTROL DEPARTMENT
WILL THE SPECIES BE INTRODUCED OR ATTRACTED BY THE PROJECT?
COMPARE WITH SIMILAR PROJECTS IN THE REGION
CAN INTRODUCTION BE PREVENTED?
IDENTIFY RELEVANT FACTORS IN SIMILAR PROJECTS
CAN THE DISEASE RESERVOIR BE ERADICATED?
CONSULT RODENT OR GAME CONTROL DEPARTMENT
WILL THE PROJECT INCREASE THE SIZE OF THE RESERVOIR POPULATION?
CONSULT RODENT OR GAME CONTROL DEPARTMENT
CONCLUSION: THERE IS/IS NOT AN ANIMAL RESERVOIR OF THE DISEASE
RETURN TO A.1. PAGE 19

B.O. DESCRIPTION OF THE DISEASE ENVIRONMENT

Flowchart A.O. has enabled you to identify the vector-borne diseases which occur in the project region. The water development project may create or enhance vector breeding sites or opportunites for human contact with vectors or unsafe water sources. In either case, the parasite transmission potential will increase. Table 2.3., page 54, indicates which vector is associated with each disease.

B.O.

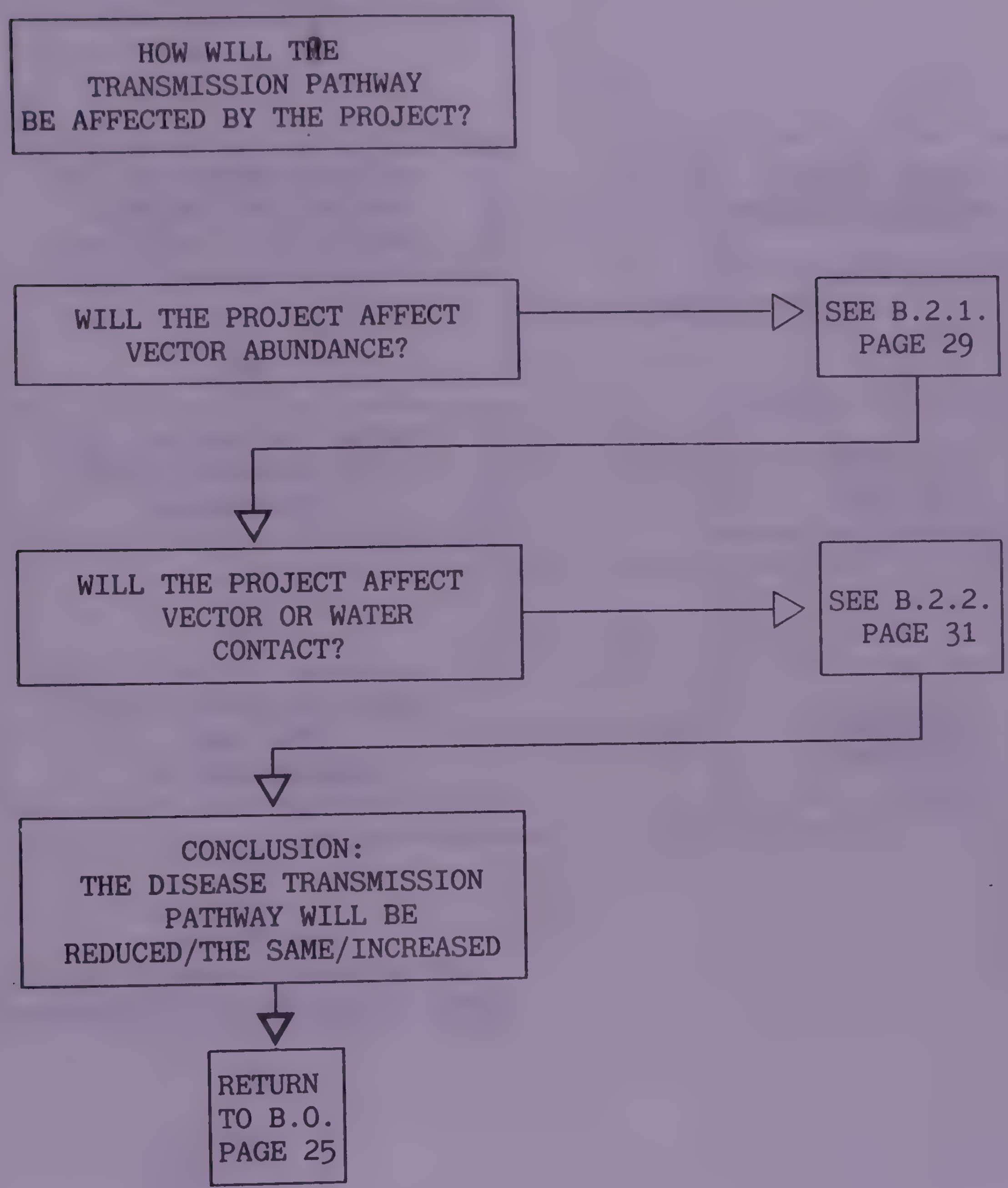

DESCRIPTION OF THE DISEASE TRANSMISSION POTENTIAL FOR EACH DISEASE IDENTIFIED
HOW IS THE PATHOGEN USUALLY TRANSMITTED?
SEE TABLE 2.3. PAGE 54
WHICH VECTOR SPECIES ARE IMPORTANT IN THE REGION?
CONSULT VECTOR CONTROL DEPARTMENT
ARE THESE VECTOR SPECIES ABUNDANT, AT LEAST SEASONALLY OR IN DISCRETE FOCI?
CONSULT VECTOR CONTROL DEPARTMENT
HOW WILL THE TRANSMISSION PATHWAY BE AFFECTED BY THE PROJECT?
SEE B.1. PAGE 27
CONCLUSION: THE DISEASE TRANSMISSION POTENTIAL SCORES:
GO TO C.O. PAGE 43

FLOWCHART B.1.

There is a transmission pathway if the vector is abundant and there is contact between people and the vector or unsafe water. Abundance may vary with season because breeding sites are reduced or entirely absent during unfavourable climatic periods. Abundance may be restricted to discrete foci where there are patches of favourable breeding sites in a generally inhospitable environment. For example, dry season water holes may harbour and concentrate the abundance of snail hosts of schistosomiasis. There may be seasonal variation in human contact with vectors or water.

Vector-borne diseases can be grouped into those requiring more or less frequent infection with the parasite to produce clinical disease symptoms. See chapter 2, bottom of page 55 and top of page 56.

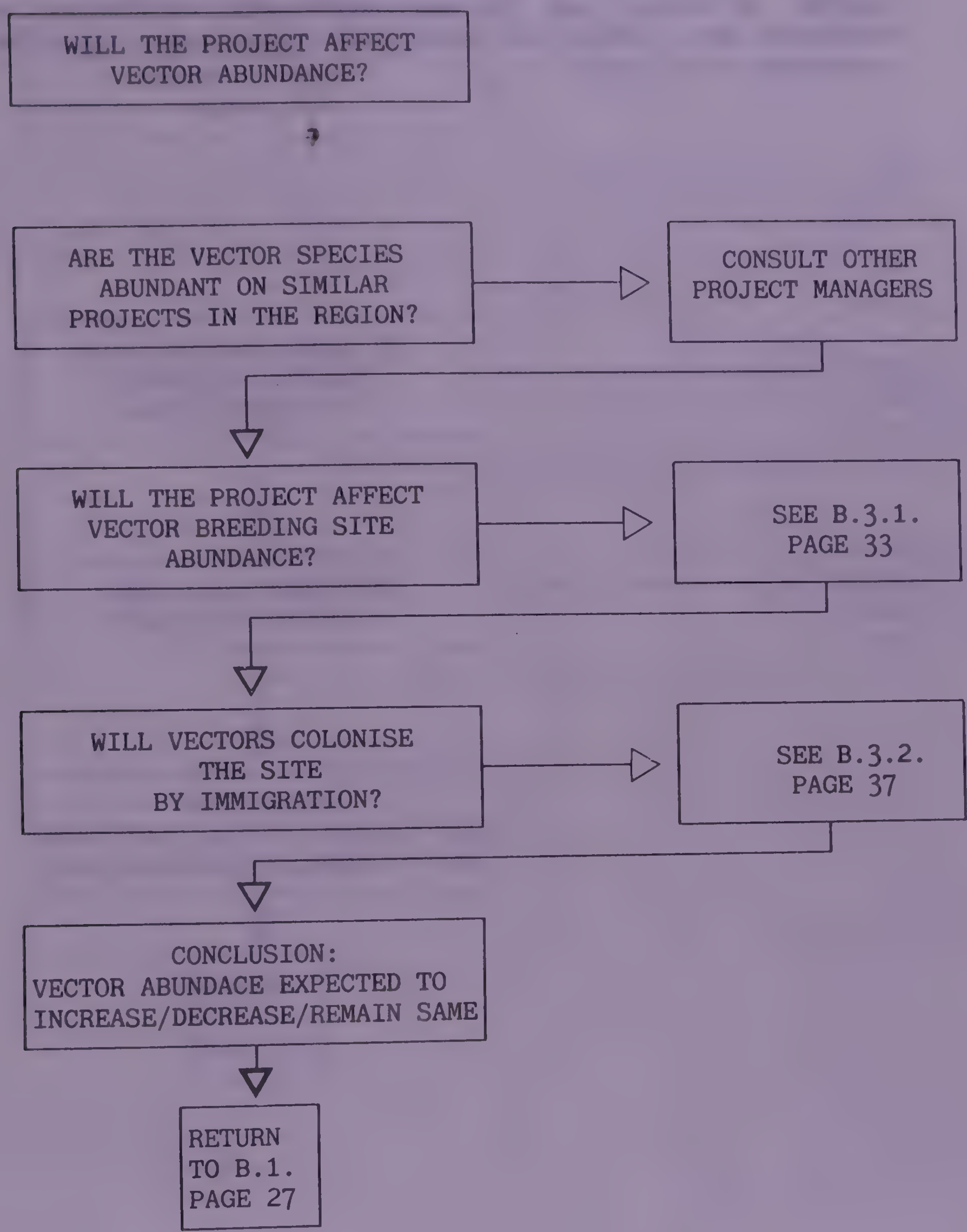
B.1.


HOW WILL THE TRANSMISSION PATHWAY BE AFFECTED BY THE PROJECT?
WILL THE PROJECT AFFECT VECTOR ABUNDANCE?
SEE B.2.1. PAGE 29
WILL THE PROJECT AFFECT VECTOR OR WATER CONTACT?
SEE B.2.2. PAGE 31
CONCLUSION: THE DISEASE TRANSMISSION PATHWAY WILL BE REDUCED/THE SAME/INCREASED
RETURN TO B.O. PAGE 25

FLOWCHART B.2.1.

Vector abundance is assumed to depend primarily on breeding site availability. One of the most reliable methods of forecasting changes in vector abundance is by comparison with conditions on similar projects within the region.

B.2.1.


WILL THE PROJECT AFFECT VECTOR ABUNDANCE?
ARE THE VECTOR SPECIES ABUNDANT ON SIMILAR PROJECTS IN THE REGION?
CONSULT OTHER PROJECT MANAGERS
WILL THE PROJECT AFFECT VECTOR BREEDING SITE ABUNDANCE?
SEE B.3.1. PAGE 33
WILL VECTORS COLONISE THE SITE BY IMMIGRATION?
SEE B.3.2. PAGE 37
CONCLUSION: VECTOR ABUNDACE EXPECTED TO INCREASE/DECREASE/REMAIN SAME
RETURN TO B.1. PAGE 27

FLOWCHART B.2.2.

Contact can be reduced by reducing the abundance of vectors (by reducing breeding sites) and by changing human behaviour. Each species of vector has its own behavioural attributes which determine when, where and under what conditions it bites or associates with people.

B.2.2.

WILL THE PROJECT AFFECT VECTOR OR WATER CONTACT?

DOES THE BEHAVIOUR OF THE VECTOR SPECIES FAVOUR CONTACT?

SEE B.3.3. PAGE 39

DOES HUMAN BEHAVIOUR FAVOUR CONTACT?

SEE B.3.4. PAGE 41

CONCLUSION:
OPPORTUNITIES FOR CONTACT WILL INCREASE/DECREASE/REMAIN SAME

RETURN TO B.1. PAGE 27

FLOWCHART B.3.1.

At the design stage there is maximal opportunity to incorporate features into the project which discourage the breeding of harmful vectors. There is also the opportunity to develop operating procedures and maintenance schedules which prevent the regrowth of vegetation, the deposition of silt or the accumulation of waste water.

Each vector species has its own preferences for breeding sites and these can be classified (see table 1.3., page 34). Human activities associated with the project can have a dramatic impact on the abundance, distribution and classes of potential breeding sites (see table 1.4., page 35).

B.3.1.

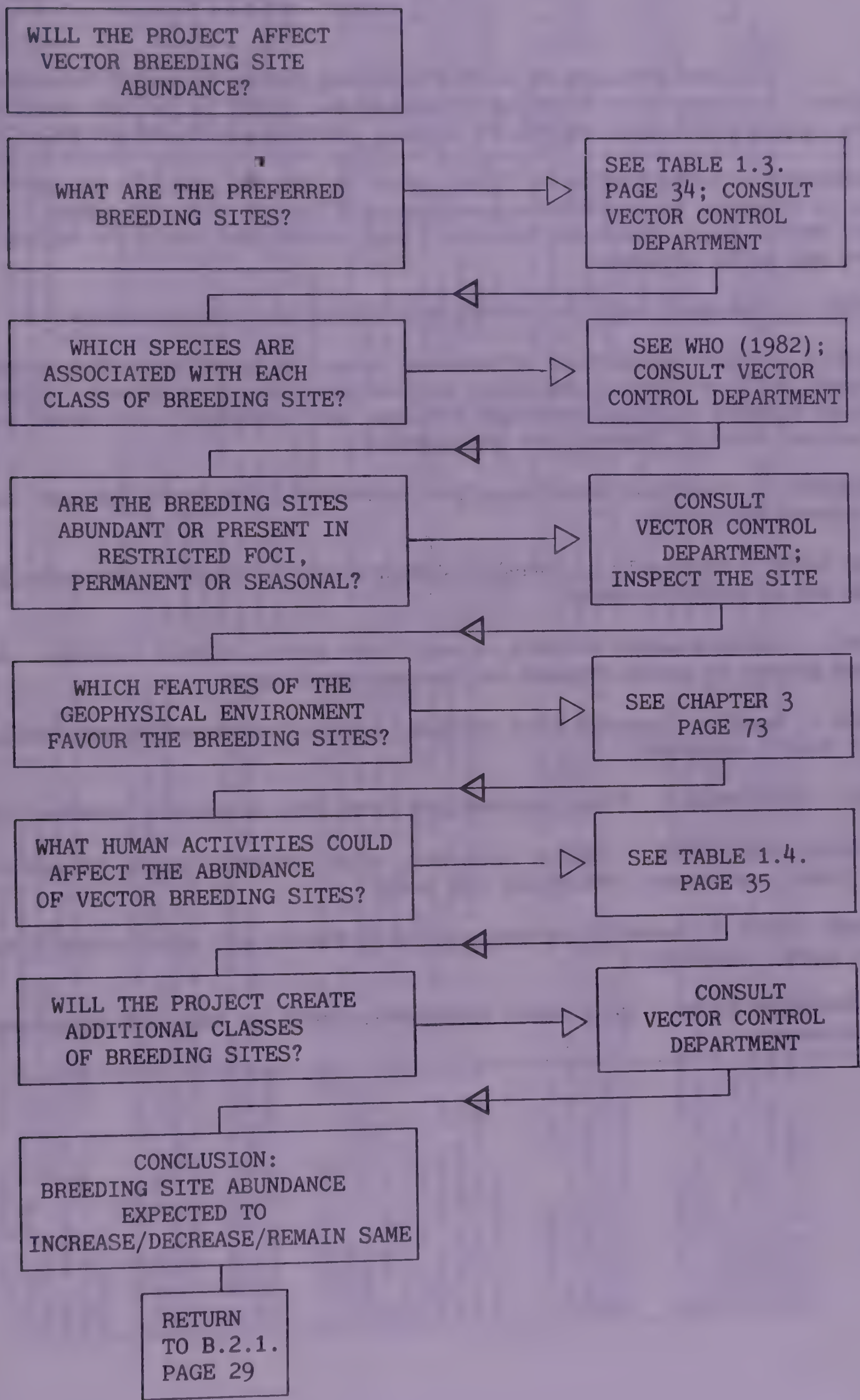

WILL THE PROJECT AFFECT VECTOR BREEDING SITE ABUNDANCE?
WHAT ARE THE PREFERRED BREEDING SITES?
SEE TABLE 1.3. PAGE 34; CONSULT VECTOR CONTROL DEPARTMENT
WHICH SPECIES ARE ASSOCIATED WITH EACH CLASS OF BREEDING SITE?
SEE WHO (1982); CONSULT VECTOR CONTROL DEPARTMENT
ARE THE BREEDING SITES ABUNDANT OR PRESENT IN RESTRICTED FOCI, PERMANENT OR SEASONAL?
CONSULT VECTOR CONTROL DEPARTMENT; INSPECT THE SITE
WHICH FEATURES OF THE GEOPHYSICAL ENVIRONMENT FAVOUR THE BREEDING SITES?
SEE CHAPTER 3 PAGE 73
WHAT HUMAN ACTIVITIES COULD AFFECT THE ABUNDANCE OF VECTOR BREEDING SITES?
SEE TABLE 1.4. PAGE 35
WILL THE PROJECT CREATE ADDITIONAL CLASSES OF BREEDING SITES?
CONSULT VECTOR CONTROL DEPARTMENT
CONCLUSION: BREEDING SITE ABUNDANCE EXPECTED TO INCREASE/DECREASE/REMAIN SAME
RETURN TO B.2.1. PAGE 29

TABLE 1.3. **A classification of vector breeding sites.** Mosquito breeding sites are emphasised. Breeding site preference depends on, inter alia, the exact degree of shading, water flow rate, amount of organic pollution. (Based on WHO, 1982).

IMPOUNDMENTS - Large bodies of fresh water in full or partial sunlight. Larvae occur in floating or emergent vegetation or floatage near the edges. Includes lakes, pools, bays, large borrow pits, slow rivers and pools in drying beds of rivers and major streams.
MARSHES - Marshes, bogs and swamps associated with impoundments.
RAINPOOLS - Small collections of seepage water, stagnant and often muddy, but not polluted; full to partial sunlight; vegetation present or absent. Includes roadside ditches, clogged drainage ditches, small borrow pits, wheel ruts, hoofprints, natural depressions and puddles.
RICEFIELDS - Seasonal breeding sites, especially important between transplanting and closure of canopy.
SHADED WATER - Partially or heavily shaded water in forests. Includes pools, ponds, swamps and sluggish streams.
STREAMS - Running water courses, clear fresh water, direct sunlight. Includes lowland grassy or weedy streams and irrigation ditches.
SEEPAGE - Springs, seepage from streams, irrigation channels and tanks; clear water; direct sunlight.
NATURAL CONTAINERS - Plant hollows and cavities; epiphytic arboreal bromeliads.
ARTIFICIAL CONTAINERS - wells, cisterns, water storage tanks, ornamental basins, tins, plastic packages, abandoned car tyres.
POLLUTED WATER - heavily contaminated with faeces and other organic waste, foul water; direct sunlight.
OTHER BREEDING SITES - many other categories could be required according to local circumstances.

Table 1.4. A classification of the effects of human activity on the environment in relation to breeding sites of vectors, with emphasis on mosquitoes.

1. WATER SURFACE - Developments increasing water surface area through the construction of impoundments, water courses and ricefields. Inadequate drainage from settlements and fields and seepage from unlined canals leading to the formation of pools and swamps; variable importance of flow rate and wave action.

2. WATER TABLE - Developments raising the water table or exposing ground water (e.g., digging shallow wells); developments promoting the formation of permanent pools and contribution to the problem of drainage.

3. SUBMERGENCE - Development of impoundments and rice fields causing old river banks and vegetation to be submerged and shorelines to be changed.

4. WATER COURSES - Construction activity involving stream stoppage and diversion; creation of irrigation and drainage channels. The number, size and length of water courses may be altered and the volume and flow rate of water may change. Water courses may be lined or unlined with steep or shallow sides and open or enclosed in pipes. Seepage water from unlined channels may increase water surface area. The banks of water courses may be affected by trampling and vegetation and this may alter the flow rate and increase seepage and pool formation.

5. MOVEMENT - People, animals and heavy equipment moving into and through the project area. Creation of roads, paths and fords; formation of depressions which collect rain or ground water; deformation of banks of water courses and margins of reservoirs by trampling.

6. SETTLEMENT - Construction and use of temporary housing, with inadequate water supplies, water storage and sanitation facilities, for use by construction workers and settlers (planned and unplanned). Provision of permanent housing for settlers which subsequently falls into disrepair. Lack of maintenance causing water supplies to be interrupted by pump failure and domestic water obtained from unprotected sources.

7. EXCAVATION AND CULTIVATION - Construction of roads, canals and ditches, clearance of trees and other vegetation, excavation of borrow pits. Cultivation practices involving ridging, banking or flooding, and causing temporary increases in water surface area.

8. AQUATIC SUCCESSION - Developments creating new aquatic habitats which are colonised by a variety of plants and animals. The plants will affect the flow of water and the margins of impoundments. The growth of vegetation may be actively promoted by agriculture (e.g., seasonal rice transplanting) or passively encouraged by inadequate maintenance such as lack of weeding activites. The animals may include harmful species such as mosquito larvae and snails and beneficial species, such as larvivorous fish. Both seasonal and longer term successions may occur and reoccur following further disturbances. Temporary inorganic pollution may cause reversion.

9. TERRESTRIAL SUCCESSION - Newly cleared land recolonised by plants and animals including grasses and shrubs and later thickets and trees. The succession may be actively promoted (e.g., planting of shade trees, annual or perennial crops) or passively encouraged by inadequate weeding, grazing of domestic animals or needs for fuelwood. The vegetation may provide habitats for wild birds and animals which are potential reservoirs of disease. Seasonal and longer term successions occur and are disrupted by activities such as grass burning.

10. ORGANIC POLLUTION - Passive or active contamination of water with domestic and agricultural waste, especially around human settlements. Disrepair of waste disposal systems, overflow of latrines; contamination by urine and faeces of wild or domestic animals contributing to disease transmission.

11. INORGANIC POLLUTION - Contamination by waste products of construction such as cement, engine oil and silt and agricultural chemicals is detrimental to both vectors and their natural enemies.

12. LANDFILL - Raising the level of low lying land for construction may cover surface water and reduce breeding sites. The soil must be excavated elsewhere creating borrow pits.

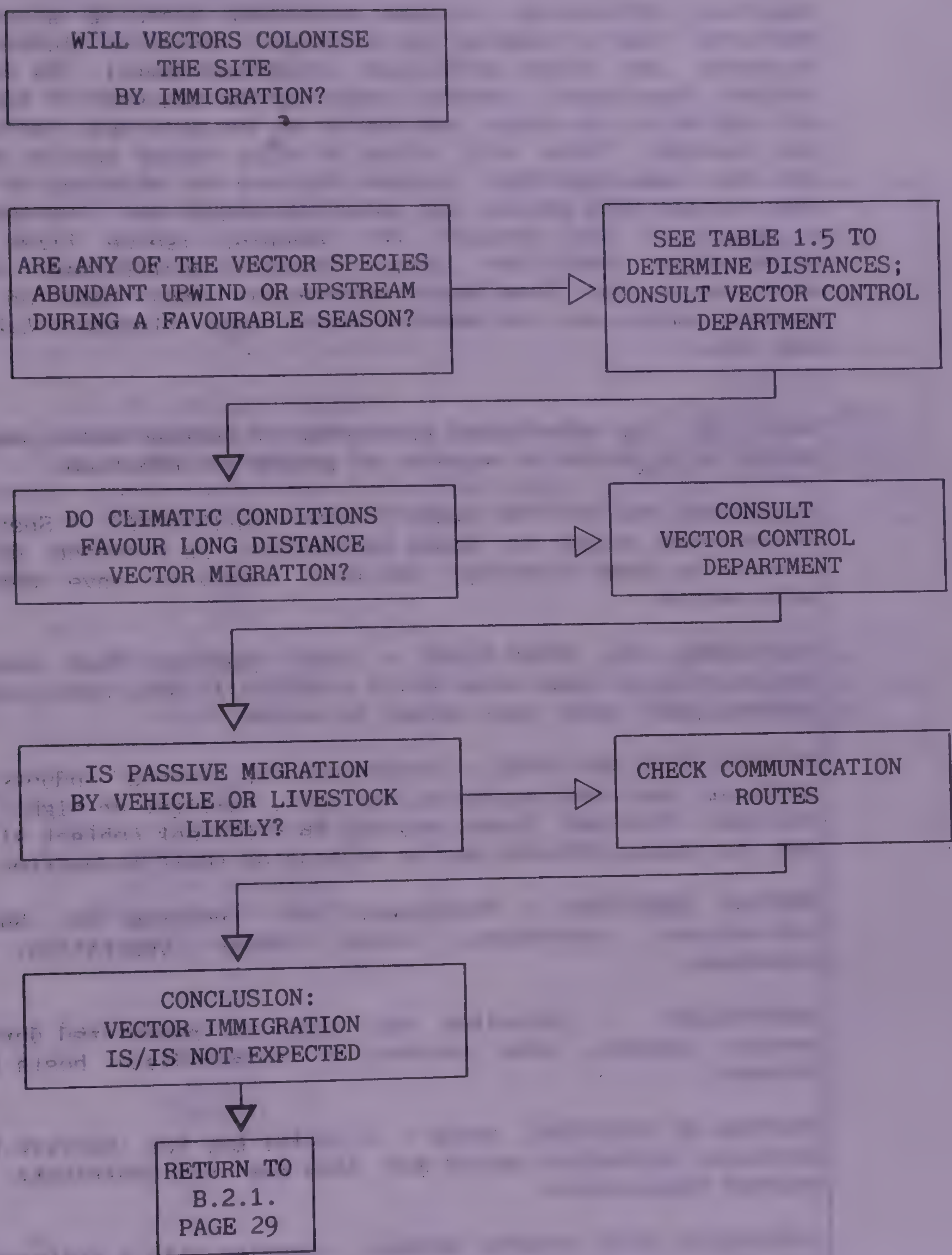
FLOWCHART B.3.2

Most vectors have enormous powers to colonise and recolonise breeding sites. Flying insects can migrate substantial distances, especially when helped by a prevailing wind, see table 1.5. below. Snails are adapted to seeking passive transport on floating materials in rivers, the legs of animals and on vehicles. If a vector or intermediate host is present in a region then, sooner or later, it will colonise or recolonise the breeding sites created by the project.

Table 1.5. **The flight range of vectors (kms).** Migratory flights are often aided by prevailing winds and occasionally much longer flights have been recorded. Local movement is indicated as a guide to settlement siting. Where a range is indicated, the majority of vectors will only travel the shorter distance.

VECTOR	LOCAL MOVEMENT (in kms)	MIGRATION (in kms)
SIMULIID BLACKFLIES	4-10	400
ANOPHELINE MOSQUITOES	1.5-2.0	50
CULICINE MOSQUITOES	0.1-8.0	50
TSETSE	2.0-4.0	10
PHLEBOTOMINE SANDFLIES	0.05-0.5	1

B.3.2.


WILL VECTORS COLONISE THE SITE BY IMMIGRATION?
ARE ANY OF THE VECTOR SPECIES ABUNDANT UPWIND OR UPSTREAM DURING A FAVOURABLE SEASON?
SEE TABLE 1.5 TO DETERMINE DISTANCES; CONSULT VECTOR CONTROL DEPARTMENT
DO CLIMATIC CONDITIONS FAVOUR LONG DISTANCE VECTOR MIGRATION?
CONSULT VECTOR CONTROL DEPARTMENT
IS PASSIVE MIGRATION BY VEHICLE OR LIVESTOCK LIKELY?
CHECK COMMUNICATION ROUTES
CONCLUSION: VECTOR IMMIGRATION IS/IS NOT EXPECTED
RETURN TO B.2.1. PAGE 29

FLOWCHART B.3.3

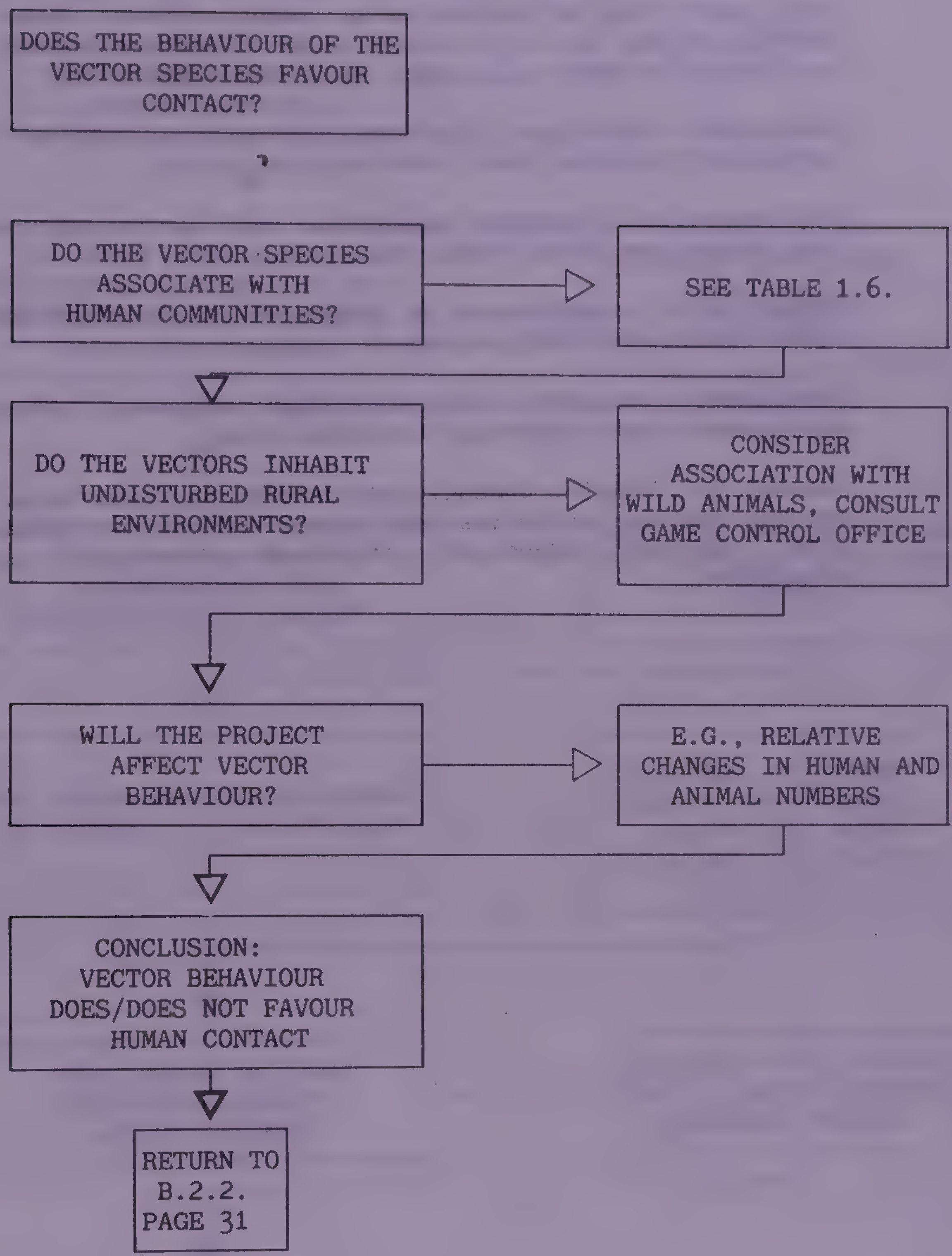
Each vector species has different habits (see table 1.6. below).

Important differences include preferred breeding sites and preferred time of feeding (day or night), location (indoors or outdoors) and blood preference (animal or human). The vector control department, usually part of the ministry of health, will advise on the names and habits of the principal vector or host species. There will often be other vector species which are far less important, because they are not abundant or have less contact with people, but whose importance may increase as a result of the project. For example, tsetse flies and phlebotomine sandflies often inhabit undisturbed rural environments far from human habitation. They feed on wild animals which may be parasite hosts (see flowchart A.2.2., page 23).

TABLE 1.6. **The behavioural attributes of vectors which promote contact with people or exposure of people to infection.**

PREFERENCE FOR HABITATS CLOSE TO HUMAN SETTLEMENTS - Species which breed close to human habitation, in breeding sites created by human behaviour, are more likely to have contact with people.
PREFERENCE FOR HUMAN BLOOD - Some species feed almost exclusively on human blood while others will only bite people because their usual host animal is scarce.
CONTACT SITES AND TIMES - Preference for feeding indoors or outdoors; host seeking during daylight, twilight or night.The village, farm and forest may all be different contact sites and the people affected may be related by their occupation.
RESTING BEHAVIOUR - Preference for resting in human habitations, out-houses, eaves, under vegetation, or elsewhere.
SEASONALITY - Parasites may only be transmitted during certain seasons, when vectors or intermediate hosts are abundant.
SURVIVAL OF INFECTIVE STAGE - A vector may not survive the extrinsic incubation period and thus may not contribute to disease transmission.
ASSOCIATION WITH DOMESTIC ANIMALS - Species with a preference for the blood or habitations of domestic animals may be brought into contact with people who, themselves, live close to domestic animals.

B.3.3.


DOES THE BEHAVIOUR OF THE VECTOR SPECIES FAVOUR CONTACT?
DO THE VECTOR SPECIES ASSOCIATE WITH HUMAN COMMUNITIES?
SEE TABLE 1.6.
DO THE VECTORS INHABIT UNDISTURBED RURAL ENVIRONMENTS?
CONSIDER ASSOCIATION WITH WILD ANIMALS, CONSULT GAME CONTROL OFFICE
WILL THE PROJECT AFFECT VECTOR BEHAVIOUR?
E.G., RELATIVE CHANGES IN HUMAN AND ANIMAL NUMBERS
CONCLUSION: VECTOR BEHAVIOUR DOES/DOES NOT FAVOUR HUMAN CONTACT
RETURN TO B.2.2. PAGE 31

FLOWCHART B.3.4.

Contact with vectors or unsafe water can occur near or far from the domestic environment. Contact near the domestic environment may be prevented by ensuring that there are no breeding sites in the vicinity. The flight range of vectors was listed in table 1.5., page 36. For example:

Settlements which are 2km from rice fields will be largely protected from rice field breeding mosquitoes;

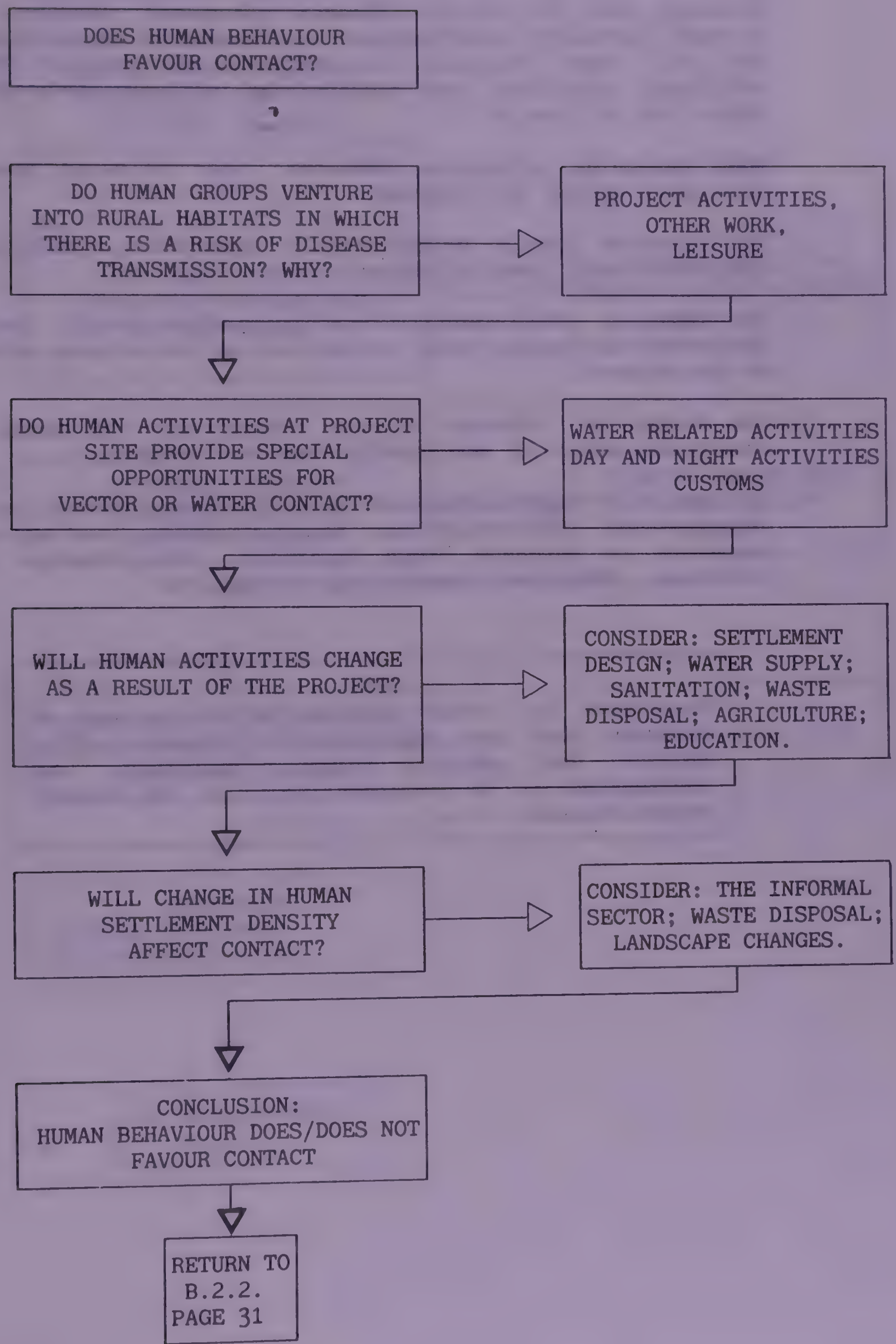
Settlements with adequate sanitation will be largely protected from mosquitoes which favour foul water;

Contact with unsafe water is prevented by ensuring that safe water points are more convenient to use;

Development projects often encourage unplanned urbanization which create many potential breeding sites;

Contact far from the domestic environment may also occur during project related activites such as agriculture or construction work. Special means of individual protection could be considered.

B.3.4.


DOES HUMAN BEHAVIOUR FAVOUR CONTACT?
DO HUMAN GROUPS VENTURE INTO RURAL HABITATS IN WHICH THERE IS A RISK OF DISEASE TRANSMISSION? WHY?
PROJECT ACTIVITIES, OTHER WORK, LEISURE
DO HUMAN ACTIVITIES AT PROJECT SITE PROVIDE SPECIAL OPPORTUNITIES FOR VECTOR OR WATER CONTACT?
WATER RELATED ACTIVITIES DAY AND NIGHT ACTIVITIES CUSTOMS
WILL HUMAN ACTIVITIES CHANGE AS A RESULT OF THE PROJECT?
CONSIDER: SETTLEMENT DESIGN; WATER SUPPLY; SANITATION; WASTE DISPOSAL; AGRICULTURE; EDUCATION.
WILL CHANGE IN HUMAN SETTLEMENT DENSITY AFFECT CONTACT?
CONSIDER: THE INFORMAL SECTOR; WASTE DISPOSAL; LANDSCAPE CHANGES.
CONCLUSION: HUMAN BEHAVIOUR DOES/DOES NOT FAVOUR CONTACT
RETURN TO B.2.2. PAGE 31

C.O. DESCRIPTION OF DISEASE MANAGEMENT PRACTICES

Complete the description of disease management practices assuming that no special disease management measures are planned. Pertinent questions are: what resources are available? How will these resources be affected by the project? Which additional resources are required to mitigate the problems identified in A and B?

When designing mitigation measures, the following general principles should be followed:-

1. The measures should be technically appropriate, culturally acceptable and community-based.

2. The community which benefits from the project should play an active decision making role in controlling the adverse effects of the project.

3. The burden of adverse effects should not be borne by communities which do not benefit from the project.

4. The available health infrastructure and personnel should not be overstretched. The project may have to provide hard currency resources to purchase drugs, equipment, transportation and buildings. Additional training may be required.

HINT

Experience has shown that an effective way of ensuring that the public health component of a project has adequate budget, continuity and independence is by incorporating it in the overall project budget.

C.O.

DESCRIPTION OF DISEASE
MANAGEMENT PRACTICES
(FOR EACH DISEASE)

ARE THERE EFFECTIVE
PREVENTATIVE MEASURES
FOR THE DISEASE?

CONSULT HEALTH AND
VECTOR CONTROL OFFICERS
SEE C.1.1.
PAGE 45

IS THERE EFFECTIVE
LOCAL MEDICAL CARE
FOR THE DISEASE?

CONSULT HEALTH DEPT.
SEE C.1.2.
PAGE 47

CAN DISTRICT HEALTH SERVICES
COPE WITH ADDITIONAL WORKLOADS
CREATED BY PROJECT?

CONSULT HEALTH DEPT.

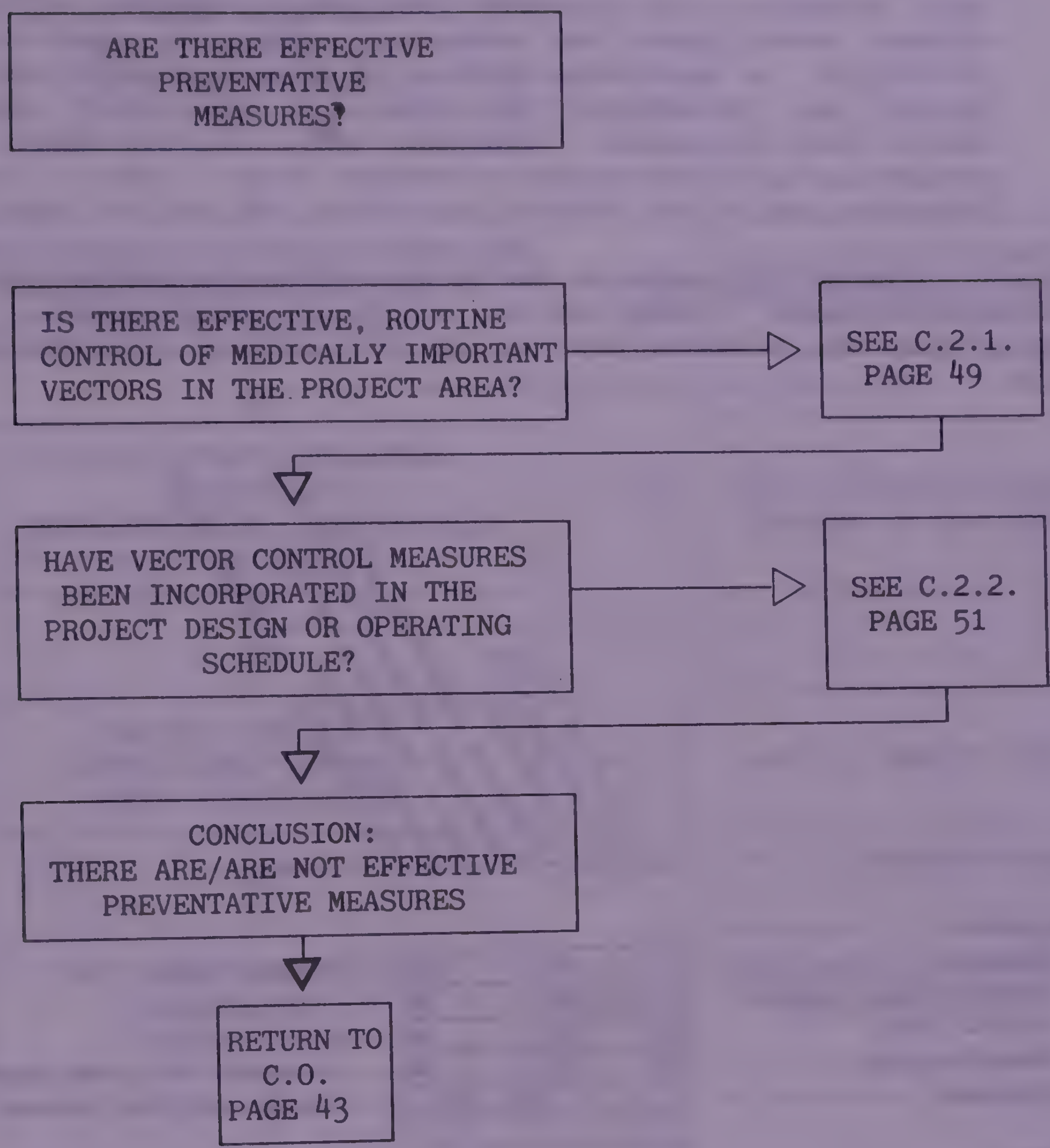
CONCLUSION:
DISEASE MANAGEMENT
EFFECTIVENESS SCORE:

GO TO WORKSHEET 1
PAGE 9

FLOWCHART C.1.1.

The most common vector management practices involve chemical control. This is usually applied to the resting sites of adult vectors or to vector breeding sites. The effectiveness of chemical control is limited by the cost of materials and application. The chemical is applied to carefully selected patches of the environment at carefully determined intervals. A skilled workforce is required to determine whether the chemical kills the pest and where selective applications are most effective. For example, adult female mosquitoes may rest indoors on walls and ceilings before or after a bloodmeal. Spraying the walls and ceilings with a residual insecticide may be a cost-effective method of control. However, only a proportion of the vector population may rest indoors. An outside resting strain may be selected relatively quickly and render the population resistant to this method of control.

C.1.1.


ARE THERE EFFECTIVE PREVENTATIVE MEASURES?
IS THERE EFFECTIVE, ROUTINE CONTROL OF MEDICALLY IMPORTANT VECTORS IN THE PROJECT AREA?
SEE C.2.1. PAGE 49
HAVE VECTOR CONTROL MEASURES BEEN INCORPORATED IN THE PROJECT DESIGN OR OPERATING SCHEDULE?
SEE C.2.2. PAGE 51
CONCLUSION: THERE ARE/ARE NOT EFFECTIVE PREVENTATIVE MEASURES
RETURN TO C.O. PAGE 43

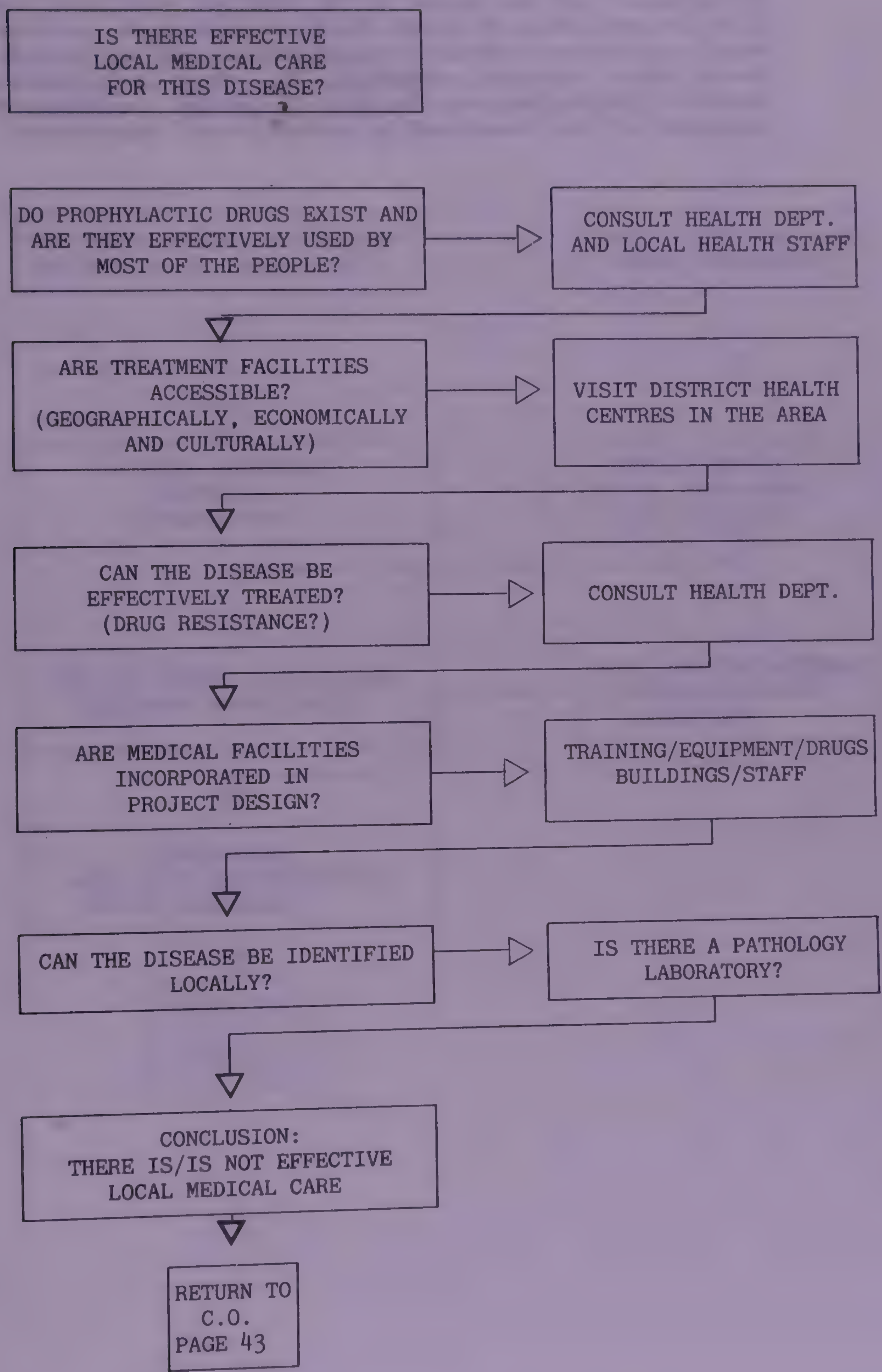
FLOWCHART C.1.2.

There may be a policy of distributing prophylactic drugs to children and other high risk groups. There may be a system of case detection and treatment but this requires efficient disease surveillance and adequate access to health care facilities. An appropriate system of disease surveillance and control may include the selection and training of village health care volunteers. Training would include blood film preparation and distribution of certain drugs. Table 1.7 below indicates some of the factors associated with medical care.

TABLE 1.7. **A broad indication of the factors affecting medical treatment of vector-borne diseases.** There are many additional complications. Relevant documents from the reference list on page 89 should be consulted for further details.

Principal disease	Vaccine available	Chemoprophylaxis	Chemotherapy	Treatment supportive only	Treatment cheap/effective/safe	Surgery in severe cases	Diagnosis simple	Hospitalization of severe cases	Notes
Arboviruses:									
Dengue				●					Usually mild
Haemorrhagic dengue				●				●	
Yellow fever	●			●				●	
Encephalitides	●			●				●	Vaccines for some forms
Dracunculiasis					●		●		Simple surgical removal
Filariasis:									
Bancroftian			●		●	●	●		Surgery when genitals involved
Brugian			●		●		●		
Loiasis		●	●		●		●	●	Drug reaction sometimes severe
Onchocerciasis			●			●	●		Drug reaction severe
Leishmaniasis:									
Cutaneous	●		●				●		Many forms self-limiting
Visceral			●					●	
Malaria		●	●		●		●	●	Drug resistance common
Schistosomiasis					●		●		Drug costs variable
Trypanosomiasis:									
African		●	●				●	●	

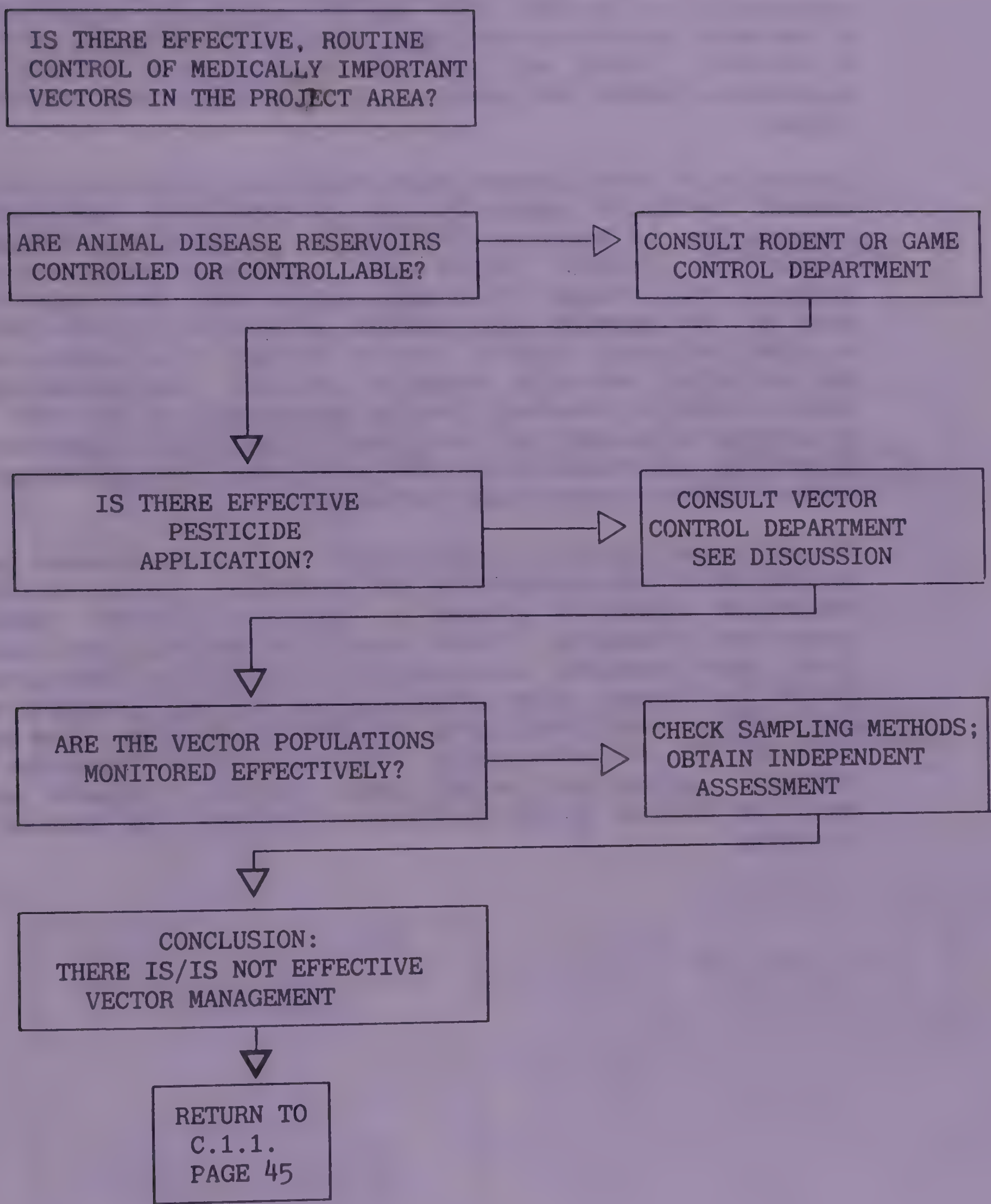
C.1.2.


IS THERE EFFECTIVE LOCAL MEDICAL CARE FOR THIS DISEASE?
DO PROPHYLACTIC DRUGS EXIST AND ARE THEY EFFECTIVELY USED BY MOST OF THE PEOPLE?
CONSULT HEALTH DEPT. AND LOCAL HEALTH STAFF
ARE TREATMENT FACILITIES ACCESSIBLE? (GEOGRAPHICALLY, ECONOMICALLY AND CULTURALLY)
VISIT DISTRICT HEALTH CENTRES IN THE AREA
CAN THE DISEASE BE EFFECTIVELY TREATED? (DRUG RESISTANCE?)
CONSULT HEALTH DEPT.
ARE MEDICAL FACILITIES INCORPORATED IN PROJECT DESIGN?
TRAINING/EQUIPMENT/DRUGS BUILDINGS/STAFF
CAN THE DISEASE BE IDENTIFIED LOCALLY?
IS THERE A PATHOLOGY LABORATORY?
CONCLUSION: THERE IS/IS NOT EFFECTIVE LOCAL MEDICAL CARE
RETURN TO C.O. PAGE 43

FLOWCHART C.2.1.

Effective pesticide application depends on a skilled workforce, adequate supplies, good maintenance of equipment and susceptibility of the vectors to the chemicals which are used. Effective monitoring of vector abundance depends on a suitable sampling method and schedule and presentation of the results in charts which indicate abundance by season and location. Research institutions may be able to provide an independent assessment of the claims made by vector control departments.

C.2.1.


IS THERE EFFECTIVE, ROUTINE CONTROL OF MEDICALLY IMPORTANT VECTORS IN THE PROJECT AREA?
ARE ANIMAL DISEASE RESERVOIRS CONTROLLED OR CONTROLLABLE?
CONSULT RODENT OR GAME CONTROL DEPARTMENT
IS THERE EFFECTIVE PESTICIDE APPLICATION?
CONSULT VECTOR CONTROL DEPARTMENT SEE DISCUSSION
ARE THE VECTOR POPULATIONS MONITORED EFFECTIVELY?
CHECK SAMPLING METHODS; OBTAIN INDEPENDENT ASSESSMENT
CONCLUSION: THERE IS/IS NOT EFFECTIVE VECTOR MANAGEMENT
RETURN TO C.1.1. PAGE 45

FLOWCHART C.2.2.

Environmental management techniques are aimed at preventing the establishment of breeding sites (environmental modification) or periodic removal of breeding sites (environmental manipulation). See WHO (1982) and FAO (1984) for a description of the many techniques available. Table 2.10 (page 72) provides a summary. There are many publications which consider the appropriate design and operation of water supply and sanitation systems.

Prevention of human contact with vectors or unsafe water may be ensured by health education, use of repellents and screens, construction of barriers and bridges, appropriate settlement design and location, piped water supplies, adequate waste disposal and changes in economic activities. See table 1.6., page 38. For example, many species of mosquitoes bite indoors at night and great benefit can be obtained by screening rooms and individual beds with mosquito netting. Room screening is impracticable in temporary housing and screens of any kind may be unacceptable under hot and humid conditions. Construction workers may sometimes be provided with protective clothing to prevent contact during their working day.

New settlements should be constructed to a high standard using designs which are appropriate and acceptable to the settlers. Homesteads should be grouped to reinforce cultural identity rather than alienation. There should be adequate provision of clean water supplies and sanitation facilities. Settlements should be distant from irrigation ditches and provided with safe bathing facilities so as to prevent children from being infected with schistosomiasis. There should be provision for vegetable gardens and animal pens. Access to unsafe water should be limited by the provision of bridges, by fencing and by zoning.

C.2.2.

HAVE VECTOR CONTROL MEASURES BEEN INCORPORATED IN THE PROJECT DESIGN OR OPERATING SCHEDULE?

DO ANY FEATURES OF THE DESIGN HELP TO PREVENT VECTOR BREEDING? → EXAMINE PLANS

DO ANY FEATURES OF THE OPERATING SCHEDULE ENSURE PERIODIC DESTRUCTION OF BREEDING SITES? → CONSULT VECTOR CONTROL DEPARTMENT

CAN THE DESIGN BE MODIFIED TO PREVENT VECTOR BREEDING? → CONSULT VECTOR CONTROL DEPARTMENT

CAN HUMAN CONTACT WITH VECTORS OR UNSAFE WATER BE PREVENTED? → SEE TABLE 1.6. PAGE 38

CONCLUSION:
ADEQUATE VECTOR CONTROL MEASURES HAVE/HAVE NOT BEEN INCORPORATED

RETURN TO C.1.1. PAGE 45

CHAPTER 2. WHAT YOU NEED TO KNOW ABOUT VECTOR-BORNE DISEASES

2.1. Regional distribution

The transmission of vector-borne diseases depends on many factors, some of which are not geographically limited. However, the distribution of vectors and reservoir hosts is strictly limited, usually according to zoogeographical boundaries. The main zoogeographical boundaries of the world are as follows (regions in brackets are largely non-tropical and can be excluded):

Nearctic	(North America), Mexico;
Neotropical	Central and South America;
Palaearctic	(Europe), N. Africa, Asia excluding India and S.E.Asia;
Oriental	India, S.E. Asia, Indian Ocean, Indonesia to Bali, Philippines;
Australasian	New Guinea, (Australia, New Zealand), Solomons, Vanauatu, other islands;
Aethiopian /Afrotropical	Africa south of the Sahara, S.W. Arabia, Madagascar.

Table 2.1 indicates (broadly) which infections are naturally transmitted within each zoogeographical region. Generally speaking, the establishment of transmission outside the normal range is very unlikely. The accompanying series of world maps indicate the distribution of disease more accurately.

TABLE 2.1. **The principal vector-borne diseases associated with tropical and sub-tropical zoogeographic regions of the world.**

PRINCIPAL DISEASE		NEARCTIC	NEOTROPICAL	PALAEARCTIC	AETHIOPIAN	ORIENTAL	AUSTRALASIAN/ PACIFIC
		ZOOGEOGRAPHIC REGION					
ARBOVIRUSES:	DENGUE	3	3	2	3	3	1
	YELLOW FEVER	2	2	1	2	1	1
DRACUNCULIASIS		0	0	1	1	1	0
FILARIASIS:	BANCROFTIAN	1	1	1	2	2	2
	BRUGIAN	0	0	0	0	2	0
	LOIASIS	0	0	0	1	0	0
	ONCHOCERCIASIS	1	1	0	2	0	0
LEISHMANIASIS:	CUTANEOUS	2	2	2	1	1	0
	VISCERAL	1	1	1	2	2	0
MALARIA		2	2	1	3	3	2
SCHISTOSOMIASIS:	MANSONI	0	2	1	2	0	0
	HAEMATOBIUM	0	0	1	2	0	0
	JAPONICUM	0	0	1	0	1	1
TRYPANOSOMIASIS:	AFRICAN	0	0	0	1	0	0
	AMERICAN	1	3	0	0	0	0

KEY: 0 = Transmission does not occur and is unlikely to become established.
1 = Transmission rare but there is a potential.
2 = Transmission widespread.
3 = Transmission occurs almost throughout the region.

2.2. Habitat

Vectors and vector-borne diseases are not distributed uniformly through a geographical region. They occur in relatively discrete patches where the habitat and climate are favourable. Table 2.2 indicates the principal habitats of the vectors or intermediate hosts associated with each of the principal diseases. It should be recognised that a development project will alter the environment and may create a habitat which was not previously present. If a disease occurs within the region and a habitat is created for the vector then, sooner or later, the habitat will be invaded by it and transmission may occur.

TABLE 2.2. The principal diseases associated with water in relation to the principal habitats of the vectors.

PRINCIPAL HABITAT

PRINCIPAL DISEASE		Arid and semi-arid lands	Rain forests	Riverain vegetation	Savanna woodlands	High altitudes	Irrigation ditches and canals	Lakes and ponds	Wetland rice cultivation	Rivers and streams	Human settlements	Savanna grasslands	Coastal plains
Arboviruses:	Dengue										●		
	Yellow fever		●								●		
Dracunculiasis								●					
Filariasis:	Bancroftian		●								●		●
	Brugian		●				●				●		●
	Loiasis		●										
	Onchocerciasis						●						
Leishmaniasis :	Cutaneous	●	●										
	Visceral	●	●								●		
Malaria			●	●			●	●	●	●	●		●
Schistosomiasis:	Mansoni						●	●	●	●	●		
	Haematobium						●	●	●	●	●		
	Japonicum						●	●	●	●			
Trypanosomiasis:	African			●	●								

2.3. How the diseases are transmitted

Vector-borne diseases may be categorised as water-based or water-related. In all cases the parasite or pathogen leaves an avian or a mammalian host and must then undergo development in an insect, crustacean or snail before entering a new avian or mammalian host. Environmental health engineering seeks to modify the environment in such a way as to prevent or reduce the transmission. Table 2.3 associates the disease with its vector. Table 2.4 explains the vector's relationship with water. Table 2.5 indicates which parasites have non-human animal hosts.

TABLE 2.3. Association between vector and disease.

		Culicine mosquito	Anopheline mosquito	Simuliid blackfly	Tabanid horsefly	Phlebotomine sandfly	*Glossina* or tsetse fly	*Cyclops*	*Oncomelania* snails	*Biomphalaria* snails	*Bulinus* snails
Arboviruses:	Dengue	●									
	Yellow fever	●									
Dracunculiasis								●			
Filariasis:	Bancroftian	●	●								
	Brugian	●									
	Loiasis				●						
	Onchocerciasis			●							
Leishmaniasis:	Cutaneous					●					
	Visceral					●					
Malaria:			●								
Schistosomiasis:	*mansoni*									●	
	haematobium										●
	japonicum								●		
Trypanosomiasis:	African						●				

TABLE 2.4. The vector's relationship with water.

Insect vectors	Culicine mosquito	Anopheline mosquito	Simuliid blackfly	Tabanid horsefly	Phlebotomine sandfly	*Glossina* or tsetse fly
Breeds in water	●	●	●			
Breeds in wet ground				●		
Breeds in damp ground					●	●
Lives near water	●	●	●			●
Lives elsewhere					●	●

Intermediate hosts	*Cyclops*	*Oncomelania* snails	*Biomphalaria* snails	*Bulinus* snails
Found in drinking water	●			
Lives in various kinds of water		●	●	●

TABLE 2.5. **The main animal hosts of vector-borne diseases.**

		Pigs	Birds	Rodents	Monkeys	Large herbivores	Carnivores	Human is principal host
Arboviruses:	Dengue				●			●
	Yellow fever				●			
	Other	●	●	●	●	●	●	
Dracunculiasis					●		●	●
Filariasis:	Bancroftian							●
	Brugian				●			●
	Loiasis				●			●
	Onchocerciasis							●
Leishmaniasis:	Cutaneous			●			●	
	Visceral			●			●	
Malaria								●
Schistosomiasis:	mansoni			●	●			●
	haematobium							●
	japonicum	●		●		●	●	
Trypanosomiasis:	Rhodesian	●				●	●	
	Gambian							●

African trypanosomiasis (sleeping sickness) has been further categorised as Gambian, which is chronic and mainly West African, and Rhodesian, which is acute and mainly East African. Diseases with a predominantly animal reservoir are referred to as zoonoses.

In the case of biting insects, transmission is further categorised according to whether the parasite is injected into the wound (malaria, leishmaniasis, arboviruses, trypanosomiasis) or escapes from the insects mouthparts while blood-feeding (filariasis). The infective stage of schistosomiasis is released from an aquatic snail into water and penetrates the skin of a person in contact with the water. Dracunculiasis is transmitted by ingesting the tiny free swimming crustacean called <u>Cyclops</u>.

The method of transmission together with the life cycle of a given parasite determines whether a low or high frequency of contact between people and vector or infected water is usually necessary in order for sufficient parasites to enter the human host to cause clinical illness. Direct injection of a pathogen into the wound is more efficient. For example, a single mosquito bite could transmit malaria, but is highly unlikely to transmit filariasis. The frequency of contact will depend on the abundance of the vector or infected water sources and the degree of contact between vector and host. In resettlement schemes the diseases requiring only low frequency contact are likely to affect the community in the earlier phases whereas the diseases requiring high frequency contact will increase in prevalence more slowly.

CONTACT FREQUENCY USUALLY REQUIRED FOR CLINICAL ILLNESS	
LOW FREQUENCY	HIGH FREQUENCY
Malaria	Filariasis
Arboviruses	Dracunculiasis
African trypanosomiasis	Schistosomiasis
Leishmaniasis.	

The diseases themselves are further classified as chronic or acute and the importance attached to each disease will vary according to political and cultural boundaries. Therefore, an acceptable level of morbidity or mortality will be determined by the ministry of health. For example, the clinical gravity and socio-economic impact of schistosomiasis depends on the frequency of re-infection which depends on the prevalence of the disease and the intensity of infection.

2.4. Mosquitoes

Mosquito vector characteristics. Mosquitoes are by far the most important family of insect vectors. The Manual on Environmental Management for Mosquito Control (WHO, 1982) contains a detailed description of their biology, importance and control. Mosquitoes are divided into two groups called anophelines and culicines.

The anophelines contain one relevant genus called *Anopheles*. The culicines contain three important genera called *Culex*, *Aedes* and *Mansonia* (see Table 2.6.) Note that only anophelines can transmit malaria, but not all anophelines do.

In common with other vectors, mosquitoes acquire the disease organism when feeding on an infected host and pass it to another host during a subsequent bloodmeal. The time taken for the organism to develop in the mosquito is temperature-dependent, usually 10-17 days. Only the female sucks blood and she does so to mature a batch of eggs. Each bloodmeal is followed by egg laying and the cycle takes 2-4 days. The cycle is repeated until the female dies. There are some 3000 species of mosquitoes of which about 100 are of medical importance. Mosquitoes are well adapted to capitalize on the environmental changes produced by water developments.

Mosquito eggs are deposited in water. The type of water preferred varies from one species to the other. Preferred sites include small containers, edges of reservoirs, sunlit rainpools, shaded water and foul water. The type of vegetation in the water is also important. Eggs hatch within days and the aquatic larvae feed on microorganisms. They are capable of rapid, wriggling movements. They must come to the surface to breathe, except for the *Mansonia* mosquito. A layer of oil on water prevents many species from breathing. *Mansonia* extracts oxygen from aquatic plants and does not come to the surface to breathe. It can be controlled by removing certain species of aquatic weeds. The larval stage of all tropical mosquitoes lasts 5-10 days. The pupal stage wriggles and breathes but does not feed. The pupal stage lasts 1-2 days. After emergence the female only mates once during her life.

Feeding habits vary considerably between species with respect to time and place and host preference. The preference for blood of a particular group of animals such as birds, bovids (cows) or pigs determines the degree of feeding on humans and the likelihood of acquiring a disease organism from an animal

TABLE 2.6. **Distribution of diseases associated with mosquitoes.**

MOSQUITO	DISEASE	DISTRIBUTION
ANOPHELES	MALARIA	THROUGHOUT TROPICS AND SUB-TROPICS
	BANCROFTIAN FILARIASIS	ASIA AND AFRICA
	BRUGIAN FILARIASIS	ASIA
	O'NYONG NYONG VIRUS	AFRICA
CULEX	BANCROFTIAN FILARIASIS	THROUGHOUT TROPICS
	ENCEPHALITIS VIRUSES	ASIA, EUROPE, AMERICAS, AFRICA
MANSONIA	BRUGIAN FILARIASIS	ASIA
	OTHER ARBOVIRUSES	AFRICA, AMERICAS
AEDES	YELLOW FEVER VIRUS	AFRICA, AMERICAS
	DENGUE VIRUS	ASIA, AMERICAS AFRICA
	DENGUE HAEMORRAGIC FEVER	ASIA, AMERICAS
	OTHER ARBOVIRUSES	ASIA, AMERICAS AFRICA
	BANCROFTIAN FILARIASIS	PACIFIC

reservoir. Malaria and bancroftian filariasis do not have animal reservoirs and only mosquitoes with a high preference for human blood are important for disease transmission. For mosquitoes with less preference, large numbers of domestic animals may act as diversionary hosts. The viruses often have animal reservoirs and are transmitted by species which prefer animal blood but which occasionally bite people. Irrigation schemes may attract such animal reservoirs to areas where there is closer contact with mosquitoes which are also biting people. The blood preference does not change but the availability of host species has changed.

Where and when a mosquito bites and where it rests after biting also has a great impact on disease transmission. Many important species feed indoors and rest indoors after feeding, making them potentially vulnerable to residual

insecticides sprayed on wall surfaces. Malaria and filariasis vectors usually bite at night and hence individuals sleeping without mosquito netting are at risk. Many of the arbovirus infections are transmitted by mosquitoes which bite outdoors and during daytime.

General mosquito control methods. The available methods of mosquito control are usually classified as chemical, biological and environmental. Chemical and environmental control may be directed against either the adults or the larvae whereas biological control is directed against the larvae. All insects develop resistance to all practical chemical insecticides eventually.

Chemical control of adult mosquitoes may be designed either to reduce abundance or to reduce the risk of parasite transmission. Attempts to reduce abundance involve space spraying and fogging and are only temporarily effective. Residual spraying involves applying insecticides with a persistent effect to all surfaces where mosquitoes are likely to rest. The residual effect may last from a few weeks to over a year. Residual spraying reduces the risk of parasite transmission by reducing mosquito longevity rather than abundance. It has been very effective at interrupting malaria transmission but only when the vector species rests on a relatively small number of surfaces which are clearly defined and accessible. For example, they may rest on cool, dark walls inside houses. Chemicals are also used as repellents and may be vaporised, as in mosquito coils, or impregnated in clothing and netting.

Chemical control of larvae, larviciding, involves spraying chemicals on a substantial proportion of the breeding sites in the environment. The residual effect is usually more limited and lasts for less than a week. Larviciding is effective at reducing adult abundance when there are relatively few breeding sites which are clearly defined and accessible. For example, some mosquitoes breed in liquid sullage and sewage associated with human communities.

Biological control consists of introducing or encouraging the predators and parasites of mosquito larvae. For example, Gambusia fish are voracious predators of mosquito larvae. If the population of the control agent can be maintained at sufficiently high numbers then the vector population may be substantially reduced. However, it is generally necessary to reintroduce the control agent at intervals of a few weeks to a few years.

Environmental management consists of reducing the number and size of mosquito breeding sites and the frequency of contact between people and mosquitoes. Mosquito breeding sites may be destroyed by measures such as draining, filling low lying areas, removing shade vegetation and fitting tight lids to water containers. Contact may be reduced by land use zoning or screening houses and beds.

2.4.1. Anopheles

Many anophelines transmit malaria and filariasis but they are less important than other mosquitoes in the transmission of arboviruses. Within any one geographical area only 2-3 species are of major medical importance and there will be important differences in their breeding sites and behaviour. Generally, anophelines breed in all kinds of relatively unpolluted water.

Environmental control methods for anopheles. Appropriate control methods vary according to the class of breeding site. The following are examples.

Anopheline mosquitoes may breed in isolated pools associated with impoundments and rivers in which the water level fluctuates. The shore line may be altered so as to minimise indentations, optimise bank slope and remove vegetation. Fluctuations in water level can be controlled by manipulation of storage reservoirs.

Anopheline mosquitoes may breed among emergent vegetation at the edges of impoundments and ditches where the larvae are protected from currents or wave action. The banks should be regularly cleared of vegetation.

Anopheline mosquitoes may breed in rice fields where mosquito productivity changes markedly with the height of the rice plants. This is extensively described in the publication Environmental Management for Vector Control in Rice Fields (FAO, 1984). Control methods include intermittent irrigation, stocking with larvivorous fishes and siting villages several kilometres from the rice fields.

Anopheline mosquitoes may breed in temporary rainpools which are widely scattered throughout the environment and impossible to remove. However, such breeding sites may be very seasonal. Control consists of the seasonal use of screens and residual insecticides.

In urban areas anophelines usually breed in 'man-made' water containers such as cisterns, wells, metal drums and ornamental ponds. Breeding is controlled by emptying containers every few days, fitting tight lids or introducing larvivorous fishes.

2.4.2. Culex

Culex mosquitoes play an important role in the transmission of a number of virus infections, many of which originate in birds. Throughout tropical Asia, India and Japan a dominant rice-field breeding Culex mosquito is the principal vector of Japanese encephalitis virus.

The common urban Culex mosquito breeds in foul water such as latrines, blocked drains and septic pools. Rapid urbanization without provision for waste disposal promotes large populations of this species. In many places it transmits bancroftian filariasis.

Methods for Culex control. Rice field breeding Culex are controlled in the same way as anophelines. The common urban species may easily be controlled by proper urban sanitation including the provision of well-designed drains, sealed septic tanks or latrines and solid waste disposal. The operation and maintenance of urban sanitation and drainage systems requires constant vigilance.

2.4.3. Mansonia

Mansonia is relatively unimportant for virus transmission. Its role as a vector is restricted to some rural areas in Asia where it transmits brugian filariasis. However, they can be an intense biting nuisance.

Methods for Mansonia control. This genus of mosquitoes is associated with aquatic vegetation and common in weed choked irrigation and drainage canals. Both emergent and floating vegetation should be removed at regular intervals.

2.4.4. Aedes

Primarily a forest group of mosquitoes, one species has become well adapted to living in close association with man. It breeds in small water collections, often artificial containers such as discarded tin cans, car tyres, water storage jars and cisterns. It is the most important vector of urban yellow fever virus, which produces occasional epidemics, and dengue or dengue haemorrhagic fever. This mosquito is likely to be present in any human settlement in the tropics where refuse disposal is indiscriminate or water supply erratic - necessitating the storage of water in jars. Forest species often breed in natural water collections in tree rot holes and leaf axils.

Methods for Aedes control. Solid waste, especially containers, should be collected and removed. Water storage jars and cisterns should be fitted with lids. Ornamental water containers and ant traps should be emptied at frequent intervals. Gutters should be kept clean and functional. Special attention should be given to the storage of potential containers. For example, used car tyre dumps are well-known breeding foci. Piped water supplies may be improved. Villages may be sited several kilometres from forests edges.

Effect of irrigation and dams on mosquito control. Water resource development in areas where mosquito vector species are already present will result in a significant increase in the extent of mosquito breeding sites. Seasonal transmission of a disease such as malaria may be extended. It should be emphasised that each species has its own peculiar biology and environmental requirements and therefore the detailed design of a water development project should take account of the attributes of local vector species.

Mosquitoes which normally breed in small collections of water, such as Anopheles gambiae in Africa, may decrease in numbers as their numerous, separate habitats are submerged. On the other hand the shallow shoreline of a large water body may provide extensive new breeding sites. The shallows become invaded by weeds and other aquatic vegetation which provide refuges against waves, wind and current action and from predators.

Deep reservoirs with regular shorelines and steeply sloped margins have a low marsh potential and are likely to support far less mosquito breeding than shallow reservoirs with a long, irregular shoreline and gently sloped margins.

Wave-wash and surface agitation are inimicable to mosquito (and snail) breeding and measures to increase their action may be helpful. On clay soils wave action may help to preserve the bank profile and increase turbidity; both measures decrease breeding.

Peripheral vegetation may require clearing, particularly close to settlements. In Africa, clearing riverine and lacustrine vegetation is an important measure in reducing contact between people and tsetse flies; for this purpose cleared strips must be of adequate size, since small clearings may actually serve as tsetse feeding sites.

The higher the marsh potential, the further away should human settlements be sited. Inadequate clearing of vegetation during construction may result in the accumulation of floating debris in inlets, the growth of aquatic vegetation and mosquito breeding. Systematic fluctuation in the water level can do much to reduce vector breeding by stranding eggs, larvae and pupae. However, if this results in the creation of temporary pools at the margins then other important mosquito vectors may be encouraged to breed.

Night storage dams pose a particular problem for disease control. During periods of irrigation, 24 hour cycles of filling and emptying will normally deter vectors. Outside the main growing period the water level may stabilise where emergent vegetation and pool formation encourage breeding.

River- and streambeds can provide breeding sites for mosquitoes in the form of dry season rock pools and as flood pools in low lying basins. Flash floods are significant features of tropical rivers and may flush larvae out of rock pools but recharge flood pools. Gabions, levees or dykes may help prevent flood pools. Sluicing and flushing by automatic syphons or hand-operated gates is often effective in preventing breeding in streams and canals.

Mosquitoes flourish in irrigation systems where there are badly designed or maintained feeder canals, smaller canals and ditches. The risk is greatest where debris and silt are allowed to accumulate and vegetation to flourish. Changes in direction, gradient and velocity may result in regions of sluggish flow where mosquitoes can breed. Vegetation may support Mansonia mosquitoes. Excessive seepage and overflow may produce water collections.

Mosquito production on irrigated land is directly related to the extent and duration of flooding of the inundated area. Intermittent irrigation deters mosquito breeding. The more sophisticated the method of irrigation the less likely it is to encourage mosquito breeding. Thus, uncontrolled flooding with little drainage presents the greatest risk, piped water the least risk.

2.5. Simuliid blackflies

There are many species of blackflies, the most important is Simulium damnosum which is the vector of "river blindness" or Onchocerciasis over most of Africa between 13°N and 13°S. There are other vector species in Africa and yet more in South and Central America.

Simuliids lay their eggs in flowing water. The aquatic larvae and pupae attach firmly to the substrate, even in violently turbid rapids. The larvae feed by filtering selectively sized particles out of the moving water. The larval stage lasts 5-10 days. The adult female fly requires blood to mature her egg batch, much like mosquitoes. They feed by day in the vicinity of the breeding site but may fly 5km in search of a suitable host. A bloodmeal is required every 4-5 days. As the rivers often dry up during the dry season, some species are able to migrate distances of more than 200km when aided by the prevailing wind.

They pick up the parasite Onchocerca volvulus when feeding on an infected person. There is no known animal reservoir. They transmit the parasite at a subsequent bloodmeal. The parasite takes about 18 months to mature in the human host and then lives and produces its infective stage for more than 10 years.

Control methods. Present methods of onchocerciasis control concentrate on killing the vector to prevent transmission. Since the larvae are sessile and limited to the fastest parts of rivers they are the easiest stage to attack. Very low concentrations of insecticide are added to the river water at these foci. The insecticide is carried down-stream by the river flow and kills all larvae over several kms.

Earlier control schemes used DDT at 0.5ppm/30 min, but more recently temephos has been adopted. After treatment the water is safe to drink and very few fish or other non-target organisms are affected. Applications are carried out every seven days.

Environmental methods of control have included clearing riverine vegetation and water management. The former method was effective for controlling Simulium neavei on one small river system in Kenya. The larvae of this species have the peculiar habit of attaching themselves to crabs. Water management techniques include controlling the spillage from dams and removing river obstructions in order to reduce water velocity and turbulence.

Effect of large structures on simulium blackfly control. Large water impoundment projects often eliminate breeding upstream by inundation of rapids. They may reduce or eliminate low water breeding downstream by stabilising discharge at higher levels than normal. Intermittent flow or large changes in discharge can kill larvae by drying them out or by flushing them away. It may be possible to incorporate insecticide injection systems into discharge pipes or to regulate flow over alternate spillways.

An unsuitable spillway design may cause massive breeding in an area where breeding was previously absent or slight. Stable discharges may lead to heavy breeding downstream all year round instead of seasonally. The human populations attracted to large schemes may include infected people who were previously absent from the area.

Effect of small structures on simulium blackfly control. Provision of adequate water supplies may reduce the contact which a community has with the river bank, where most biting occurs. There are few other advantages.

Such projects may encourage breeding in areas where it did not exist before. A poor spillway design may provide excellent breeding sites. Downstream scouring of river beds may expose rock which forms a suitable breeding substrate. The periods of flow in normally intermittent streams may be increased. Small dam outlets are very difficult to treat with insecticides.

The disadvantages can be minimised by thoughtful design. Structures must be strong enough to avoid leaks and fractures. Inclined planes on spillways must be avoided. Vertical or over-hung spillways are best. Discharge should be into deep still pools or into smooth channels with low water velocity. Perforated pipes for insecticide application can be incorporated during the construction phase.

2.6. Phlebotomine sandflies

The term sandfly is applied to two quite different groups of biting flies.

The ceratopogonid sandflies are minute midges (<1mm) which often occur in enormous numbers. They are a nuisance but not important for human disease transmission.

The phlebotomine sandflies are a little larger (1-4mm). They hold their wings in a V above their backs and make short hopping flights. They are usually active in dark places or at night. They are important vectors of all forms of leishmaniasis. They also transmit a virus causing sandfly fever and a bacterium causing Oroya fever which is restricted to a few Andean valleys.

Unlike most other biting flies, sandflies avoid free water. Their eggs are laid on damp surfaces and their larvae require a humid atmosphere in which they browse on decaying organic matter. Little is known of the precise breeding site requirements of sandflies. They breed in deep cracks in the ground, in rodent burrows, termite hills, organic debris in tree holes or in the leaf litter of South American forest floors.

Most important Old World species live in arid or semi-arid areas in close association with the desert rodents on which they normally feed. These areas are commonly highly attractive for irrigation projects which have brought large numbers of labourers followed by settlers into previously uninhabited areas and exposed them to the bite of sandflies and thus to infection with leishmaniasis. In addition, some species of sandflies live in close association with human settlements and feed on people or domestic animals.

Rodents of the genus Meriones, as well as Rhombomys opimus and Psammomys obesus are ideal hosts for sandflies across the entire Old World arid belt, from the northern edge of the Sahara desert to Mongolia and Northern India. These animals provide a reservoir of leishmaniasis. Habitats suitable for the rodents are usually in low lying areas with deep, friable alluvial or loess soils which lack only water before becoming highly productive.

Agricultural development associated with water resource development affects the sandflies in two main ways. Ploughing and other land disturbances eliminates Rhombomys or Psammomys which are the two main reservoir hosts of cutaneous leishmaniasis, but often encourages Meriones to increase in numbers and therefore become more important. The second effect comes with the raising of the water table which encourages a sandfly species which is the most efficient vector of rural cutaneous leishmaniasis.

Serious outbreaks of cutaneous leishmaniasis associated with water development projects have been reported from Libya, Saudi Arabia, USSR, Pakistan and India. In USSR participation of public health engineers and landscape epidemiology teams in development projects has led to effective control and prevented outbreaks amongst labourers and settlers.

In the New World, the vectors and the reservoirs are most abundant in primary and secondary forest. Exposure to leishmaniasis is the result of intrusion into the forest and has no specific connection with water resource development. Forest destruction eliminates the cutaneous leishmaniasis vectors but encourages a vector of visceral leishmaniasis.

Phlebotomine sandfly control

Most phlebotomine sandflies are very susceptible to insecticides and urban populations have been controlled as a by-product of malaria control campaigns using residual spraying. However, most control campaigns have concentrated on the rodent or canine hosts. Colonies of wild rodents have been destroyed by poisoning or bulldozing prior to agricultural land development.

2.7. Tsetse flies

Tsetse flies, or Glossina, are large, stout flies with a painful bite and are only found in sub-Saharan Africa (15° N to 20° S, extending to 30° S on the eastern seaboard). They transmit African trypanosomiasis to people

(sleeping sickness) and livestock (nagana). Tsetse feed on a wide range of mammals, birds and reptiles. Adults rest on shaded trees and hunt by sight on open ground, often following vehicles. They seldom venture far into open spaces and a clearing of 0.5 - 4.0 km is often an effective barrier. They give birth to live off-spring which burrow into damp shaded patches of soil or leaf litter.

Broadly speaking, West African tsetse fly species feed on people and reptiles, inhabit lacustrine or riverine woodlands and transmit gambian sleeping sickness which is not a zoonosis. There are foci of infection at wooded river crossings, water holes and lake shores. East African tsetse fly species feed mainly on wild animals, inhabit dry savanna woodlands, forestry plantations, thickets and hedges and transmit rhodesian sleeping sickness which is a zoonosis. The bushbuck is an important host of tsetse flies and a reservoir of rhodesian sleeping sickness.

Control methods. Tsetse flies are controlled by selective application of insecticides, traps or bush clearance. Wholesale bush clearance is effective but harmful to the environment. Selective and partial bush clearance involves removal of specific shade trees, undergrowth or creation of clearings which tsetse flies cannot cross. Tsetse fly populations are often diminished by water resource development but sleeping sickness remains a problem where groups of people venture into wooded areas. As epidemics can occur rapidly there is a need for constant vigilance. Chemoprophylaxis can be provided for groups such as construction workers.

2.8. Tabanids (horseflies or deerflies)

Tabanids, also known as horseflies or deerflies are large, stout flies with a painful bite. In Central and Western Africa members of the genus *Chrysops* transmit a filarial nematode which causes loasis. The disease is characterised by transient cutaneous swellings.

Tabanids breed in the mud and decaying vegetation of forest swamps. The adults are active by day, often in bright sunshine. Larval control is difficult and includes clearing shade vegetation and draining swamps. Personal protection against bites can be affected by screening houses, wearing long trousers and using repellents.

2.9. Cyclops

These are tiny free swimming creatures which contaminate fresh water. Several species are intermediate hosts of the worm which causes dracunculiasis. The portal of entry into the human body is by the mouth. People may swallow infected *Cyclops* when drinking water. Once inside the digestive tract the larvae are released and migrate into the human body. The gravid female parasites usually live in the skin of the legs and feet, under a blister. When in contact with water, the eggs of the parasite are released and contaminate the water. Chronic infection causes ulceration.

Control methods. Transmission occurs where drinking water is drawn from shallow wells or ponds into which people wade to fill their containers. *Cyclops* live in stagnant water with a high organic content. Control may be obtained by protecting drinking water, sieving contaminated water or killing *Cyclops* with a safe insecticide such as temephos.

2.10. Snails and schistosomiasis (bilharzia)

The three principal forms of schistosomiasis are listed in table 2.7 but there are other forms with restricted foci. The parasites lodge in the veins of either the intestines or the urinary tract and the eggs are passed in either the faeces or urine. The eggs hatch in water and the mobile larva (miracidium) seeks out and enters the aquatic snail. Multiplication takes place and the infective stage (cerceriae) are emitted after about 3-8 weeks. The snail may survive and remain infective for upto six months. The free swimming cerceriae are active in the water for 12-48 hours during which time they can penetrate the skin of a person who enters the water and cause infection. Cercerial emission is stimulated by warmth and light and usually occurs between 10 am and 2 pm, peaking at noon - the most dangerous time to enter unsafe water.

Each of the three genera of snails contains many species and each species contains many strains which vary in their susceptibility to the parasite. A particular water body could contain different species of snails, only some of which are medically important.

TABLE 2.7. **The principal genera of snails and the principal form of schistosomiasis which they transmit.**

SNAIL GENUS	PARASITE	TYPE OF DISEASE
ONCOMELANIA	S. JAPONICUM	INTESTINAL
BIOMPHALARIA	S. MANSONI	INTESTINAL
BULINUS	S. HAEMATOBIUM	URINARY

Snail habitats. Of the important intermediate host species, oncomelanian snails are amphibious and can be found in considerable numbers on wet ground, the others are aquatic. Some species of snails can survive the drying up of temporary pools by hiding in the mud. Biomphalaria snails like stable, slowly flowing water and are predominant in long established water bodies. Bulinus snails like unstable, semi-stagnant water and colonise newly inundated water bodies. Other favourable conditions for snails are listed in table 2.8.

TABLE 2.8. **List of favourable habitat requirements for aquatic snails (Bulinus and Biomphalaria).**

Moderate light penetration. Little turbidity. Partial shade. Water velocity less than 0.3m/s. Slight pollution with excreta. Gradient less than 20m/km. Temperature range 0 - 37 C. Optimum temperature range 18 - 28 C. Firm mud substrate. Gradual change in water level.

Snail control. Snails may be controlled by chemicals, biological agents or environmental engineering. Synthetic molluscicides are effective but very expensive and may kill fish. Natural molluscicides, from plant extracts, and biological agents (such as competitive snails) are not fully developed. Engineering methods of snail control are most important and should be incorporated at the project design stage. Some of the most important are listed in table 2.9.

TABLE 2.9. **List of principal engineering methods for vector control. See WHO (1982) for further details.**

CANAL DESIGN
Straight canals to eliminate standing pools. Mechanical screening of water intakes against snails. Bridged crossing points. Built-in chemical dispensers at strategic points. Vegetation clearance. Seepage control.
RESERVOIR DESIGN
Minimum night storage reservoirs. Periodic drawdown. Vegetation clearance. Spillways. Inundation of breeding sites. Steep, regular banks.
IRRIGATION AND DRAINAGE DESIGN
Increase water velocity, but prevent scouring. Desilting and vegetation clearance to prevent slow water flow and to remove food for snails. Proper field drainage. Maintenance of field drains. Lining major water contact points. Sprinkler irrigation if feasible. Filling surface water collections. Intermittent irrigation.
SETTLEMENT DESIGN
Properly sited villages. Piped water supplies. Properly designed and located latrines to ensure effective use and to prevent sewage entering water system. Fencing and zoning. Childrens swimming pools and other recreation sites.. Communal laundaries. Waste disposal. Home construction materials and design. Pathways and bridges. Domestic animal pens.
EARTHWORKS
Diking, drainage, grading and infilling.

Water contact. People come into contact with unsafe water through three broad categories of activity.

* Recreation, such as swimming.
* Occupation, such as irrigated agriculture, fishing and crossing water.
* Domestic, such as fetching water, washing clothes and bathing.

The water is made unsafe by pollution with human excreta. This occurs through ignorance, overcrowding, indiscriminate urination and defaecation and poor siting of settlements. Children, especially teenage males, are the principal sources of infection because of the desire to bathe and play.

Control of schistosomiasis. Schistosomiasis may be controlled by treatment, reduction of water contact, reduction of contamination by health education and sanitation and by removing snails. Treatment is beneficial to individuals, particularly those who are heavily infected, by reducing the risk of developing severe chronic diseases. However, the long term effect on transmission will be minimal if neither the entire population is treated nor the health service infrastructure is able to provide periodic examination and treatment. The cost of treatment is constantly decreasing so that health services can contribute to control with minimal hard currency support.

Reduction in water contact is best achieved by the availability of alternative water supplies for domestic needs. Prevention of water contact is difficult especially among children. Health education should be directed towards:

1. changing people's understanding of their role in causing schistosomiasis by poor hygiene;
2. encouraging people to change their habits of defecation and urination;
3. promoting self-help groups to construct water supply and sanitation facilities.

In many water resource development projects water supply and sanitation is relatively inexpensive in relation to overall development costs and will benefit the health of the community as well as the workers. Siting settlements more than 2km from irrigation systems can be effective if adequate sanitary facilities are maintained. Peripheral housing, or unplanned settlements, with inadequate sanitation, poor drainage and stagnant water bodies are important sites of transmission. Bridges at major crossing points, fencing and provision of recreational swimming facilities are all effective if adequately maintained.

2.11. Safeguards and mitigation measures

Safeguards are interventions which are intended to prevent health hazards from developing. In contrast, mitigation measures are interventions which are intended to make health hazards less severe. The decision-maker will always be faced with a choice between alternative interventions, including the choice of doing nothing. Therefore, there will always be a need to summarise the beneficial and detrimental effects of interventions, their relative costs and their effect on non-health related factors, such as agricultural productivity.

2.11.1. Whose responsibility is health?

Experience has shown that the responsibility for the health component of a water resource development project oftens falls between different administrative structures. There is an urgent need for appropriate administrative structures in which responsibility for health is clearly defined.

2.11.2. When to intervene

(a) Design phase

The obvious time to incorporate safeguards into a development project is during the design phase, before the health hazards have developed. The vector-borne disease implications should be forecast first, assuming no special health precautions will be taken; the forecasting exercise should be repeated considering each alternative group of health safeguards. The design of permanent structures will have the most long term impact on health. Health authorities should approve and countersign the plans before construction commences, if this can be organised without undue delays.

(b) Construction phase

During the construction phase special skills will be required and the work force will often be recruited by the engineering contractor. The health of the recruits and their immune status will determine whether construction proceeds in a smooth and timely fashion. The contractor may be responsible for the health of the work force and their families. The increased economic activity may attract unplanned settlers who sell goods and services to the recruits. The contractor should screen his new employees and may offer treatment as part of the labour conditions.

Temporary accommodation on and off the worksite may provide plenty of opportunity for vector breeding. Proper water supply should be considered a basic requirement for temporary workers. In addition, the contractor may instigate special control measures.

(c) Operation phase

During the operation phase the responsibility for health is likely to be transferred progressively to the ministry of health. However, it takes time to train or redeploy personnel and to construct dispensaries and accommodation. Therefore, it is the planners' responsibility to communicate with the health authorities at an early stage.

The project managers should remain responsible for maintenance and operating procedures which reduce health risks and be accountable to the health department.

2.11.3. Where to intervene

Figure 2.1. illustrates the changes which may occur during a water resource development project. Intervention may be possible at any of these points. Figure 2.2. on page summarises the transmission pathways for several vector-borne diseases.

Changes in vector and water contact . The project should be designed so as to minimise vector contact. Contact between people and vectors may be increased or decreased by changes in human behaviour, changes in vector behaviour or changes in vector abundance. Each species of vector has preferred locations and times for seeking a blood-meal. For example, human contact with tsetse flies may occur when people venture into or near relatively undisturbed woodlands during daylight. As another example, contact with some species of mosquito may occur when people are sleeping inside their houses during the night.

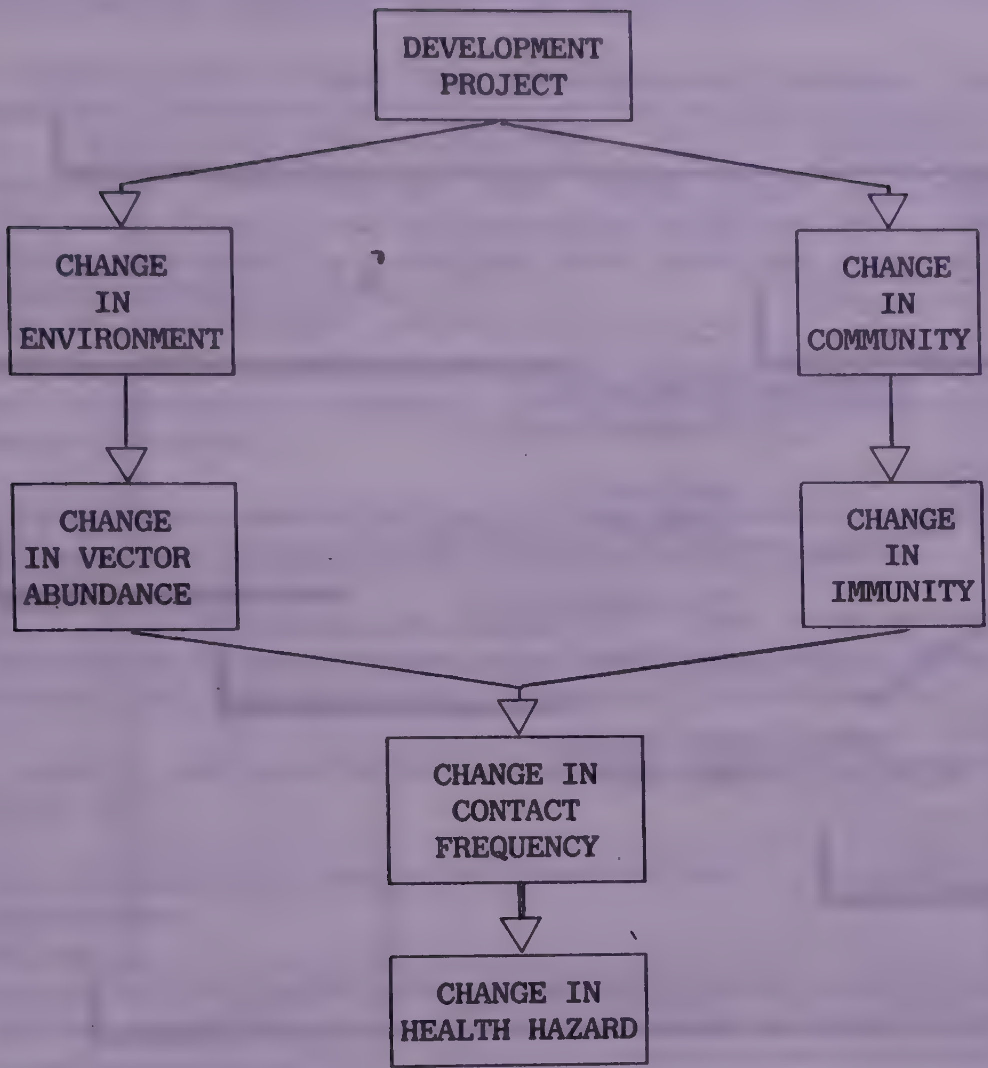


Figure 2.1. How water development can affect human health.

The project should be designed so as to minimise contact with unsafe water. Contact between people and water containing intermediate hosts may be increased or decreased by changes in human behaviour or changes in abundance of the intermediate host. In the case of schistosomiasis, water must first be polluted by the urine or faeces of infected people, before the transmission cycle of the disease can become established; the other indispensable condition is the presence of the suitable snail species.

Changes in terrestrial breeding sites. Changes in terrestrial habitats may affect the breeding sites and hence abundance of insect vectors or animal reservoir hosts. For example, phlebotomine sandflies breed in the burrows of certain species of rodents which may be reservoirs of the *Leishmania* parasite. The rodents favour certain kinds of topography, soil and vegetation. Similarly, tsetse flies breed in relatively moist and shaded patches of an otherwise hot and dry environment. Savannah tsetse flies feed on large game animals such as bushbuck which may be reservoirs of trypanosomes.

Changes in aquatic breeding sites. Changes in aquatic habitats may affect the breeding sites and hence abundance of both intermediate hosts and insect vectors. For example, mosquitoes and simuliid blackflies both breed in water and transmit malaria and filariasis directly between people. Some species of mosquitoes also feed on birds or animals which may be reservoirs of arboviruses. Snails and *Cyclops*, the intermediate hosts of schistosomiasis and dracunculiasis, also breed in water.

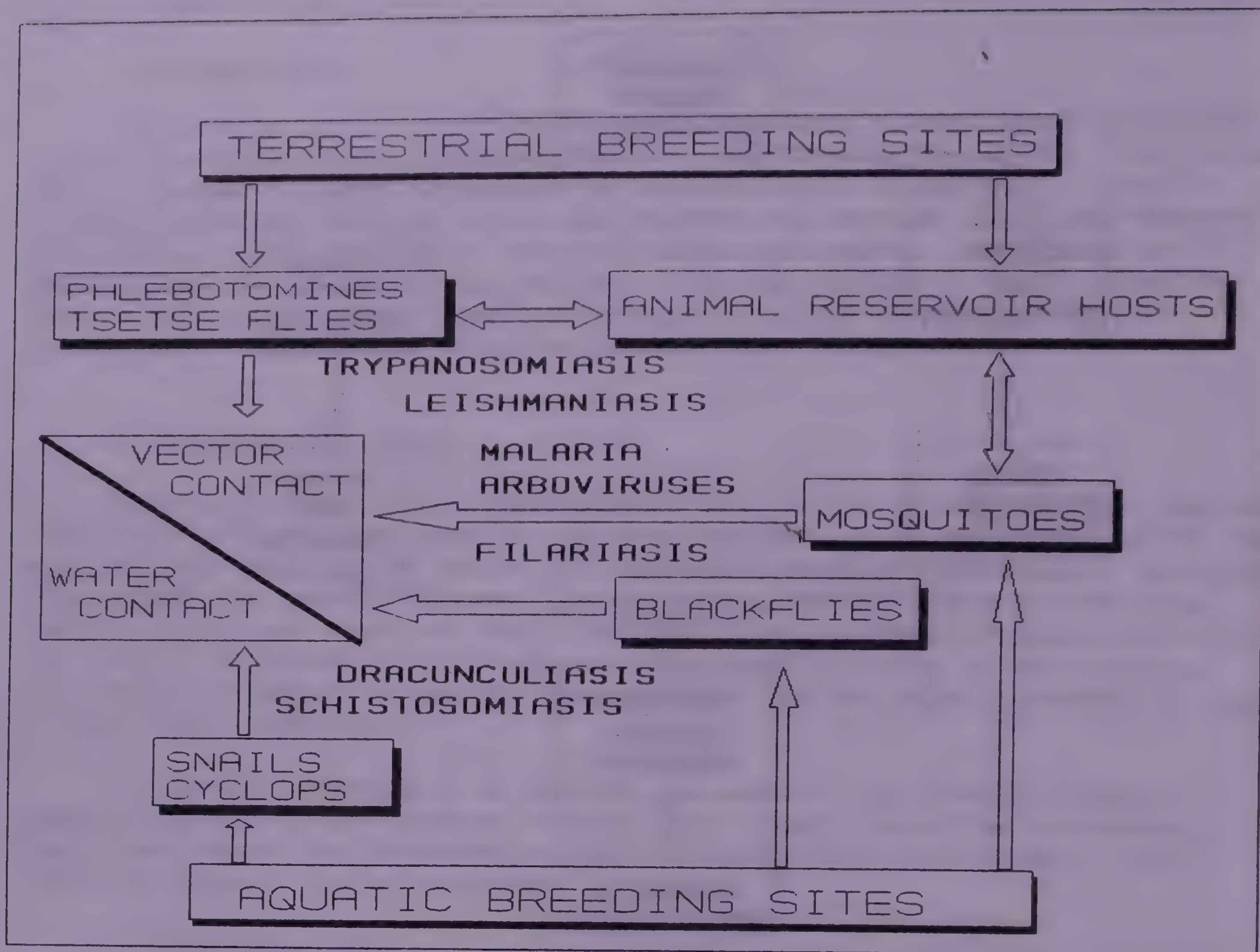


Figure 2.2. The pathways by which water resource development projects affect vector-borne disease transmission.

2.11.4. Appropriate interventions

Careful design of water development projects should help ensure that the abundance of important vector and host species is low and that human contact with vectors and infected water sources in minimised. The most appropriate interventions are multi-sectorial and have the following attributes.

(a) They reduce several health hazards simultaneously.

(b) They have a positive impact on other, not health related, activities or problems. In this case the costs of implementation, which might otherwise not be affordable, may be shared. For example, the water management principles required to maintain economic productivity in irrigation systems also reduce the risk of schistosomiasis. These principles include measures to avoid erosion, sedimentation and water logging.

The least appropriate interventions conflict with other objectives. In this case a trade-off would be necessary.

WHO (1982) have classified environmental measures into 3 primary groups.

Environmental modifications are large scale or permanent alterations to the environment aimed at preventing, eliminating or reducing vector habitats. Although long-lasting, such works may still require proper operation and maintenance.

Environmental manipulations consist of any planned recurrent activity aimed at producing temporary conditions unfavourable to vector breeding sites or habitats.

Modification or manipulation of human habitation or behaviour is intended to reduce human contact with vectors or unsafe water.

Table 2.10 illustrates some examples of these interventions and the groups of vectors on which they may have beneficial impact. Other examples of interventions are scattered throughout the document.

In summary, safeguards and mitigation measures consist of a judicious mixture of:

* High standards of design and construction.
* Maintenance.
* Siting.
* Appropriate administrative arrangements which aim to integrate available control measures.

The other guidelines in this series should be consulted for further details.

2.12. Evaluating and monitoring

One of the most important safequards which can be incorporated into a water development project is an effective scheme for monitoring and evaluating the vector population, disease prevalence and control operation during every project phase.

Forecasting and decision-making processes require revision in the light of new information. However, monitoring must be selective as it requires scarce resources. The objective should be to provide relevant information. The catchword is "optimal ignorance". Monitoring should ideally be started during the feasibility study so that hard data, representing one whole year of baseline studies, is available before the design is finalised.

Evaluation and monitoring of health related factors is clearly the responsibility of the ministry of health and emphasises, again, the need to establish intersectoral linkages.

Table 2.10. **Examples of interventions which are designed to control vectors and the vector groups which may be affected** (WHO, 1980).

VECTOR GROUPS AFFECTED

		Anopheline mosquitoes	Culicine mosquitoes	Simuliid blackflies	Tabanid horseflies	Phlebotomine sandflies	*Glossina* or tsetse flies	*Cyclops*	Aquatic snails
Environmental modification	Drainage	●	●		●				+
	Earth filling	●	+		●				+
	Deepening and filling	●	+						●
	Land grading	●	+			●			+
	Velocity alteration	+	+	+					+
	Small impoundment			–					
	Large impoundment			●					
Environmental manipulation	Clearing trl vegetation	+	+				●		
	Shading or exposing	+	+						
	water level fluctuation	+	+						+
	Sluicing/flushing	+	+						+
	Clearing aqc vegetation	+	+						+
	Salinity regulation	●	+						+
Modification of human habitation	Water supply/sewerage	+	●	+				●	●
	Screening	+	+		●				
	Refuse collection	+	●						
	Zoning	●	+	+		●	●		●
	Improved housing	●	+						

Key
- ● Primarily effective
- \+ Partially effective
- – Detrimental

CHAPTER 3. RULES-OF-THUMB WHICH MAY BE USEFUL FOR ASSESSING THE DISEASE SITUATION, ENVIRONMENT AND MANAGEMENT PRACTICES.

Introduction

Specialist knowledge often includes rules-of-thumb, or heuristics. These are approximations, valid when a combination of conditions are satisfied, which suggest a possible outcome to a series of events. In the following we have simplifed these rules as though they were always true or false. In reality, the degree of certainty will depend on the context.

The rules are grouped under the following main headings.

1. Geophysical factors;
2. Biotic factors;
3. Demographic, social and cultural factors;
4. Infrastructure;
5. Disease management by vector control.

Additional sub-headings are used where appropriate. For example, geophysical factors include a water sub-heading which is sub-divided further as: scarcity; chemistry; surface; canalisation; collections; impoundments; drainage and sullage; ground water; and irrigation.

Table 3.1. (page 74) provides a cross-index to the rules. It indicates whether there are rules under a factor heading which refer to a particular vector, disease or animal host.

1. GEOPHYSICAL

1.1 Season

1. IF the climate is seasonal THEN vectors may vary in abundance through the year.

2. IF malaria is stable THEN additional vectors may not affect the incidence of malaria significantly.

3. IF there is a season during which vectors and snails are unable to breed THEN disease transmission may be interrupted during that season.

4. IF the seasonal abundance of standing water is increased THEN the period of interrupted transmission is reduced.

5. IF domestic animals, such as cattle, buffaloes and pigs are seasonally abundant THEN they may divert vectors away from human hosts.

6. IF the development project alters the abundance of domestic animals THEN the diversionary effect is altered.

7. IF people sleep outside during hot weather THEN they may attract outdoor biting mosquitoes.

Table 3.1. Index to rules-of-thumb listed in chapter 3.

		VECTORS							DISEASES						ANIMALS
		Mosquitoes	*Simulium* blackflies	Phlebotomines	Tsetse	Tabanid flies	Snails	*Cyclops*	Arboviruses	Filariasis	Leishmaniasis	Malaria	Schistosomiasis	Trypanosomiasis	All types
1.00	Geophysical														
1.10	Season	●					●					●	●		●
1.20	Temperature								●	●		●	●		
1.30	Wind	●	●				●								
1.40	Humidity	●	●	●	●					●					
1.50	Rainfall	●	●				●					●			
1.60	Topography	●	●				●								
1.70	Soil type	●					●								●
1.80	Water														
1.81	Scarcity	●					●								
1.82	Chemistry	●	●				●								
1.83	Surface	●					●								
1.84	Canalisation	●	●		●		●						●		
1.85	Collections	●					●		●				●		
1.86	Impoundments	●	●				●								●
1.87	Drainage/Sullage	●					●								
1.88	Ground water	●													
1.89	Irrigation	●		●			●				●	●	●		●
2.00	Biotic														
2.10	Vegetation	●					●		●		●	●	●		●
2.20	Succession	●					●								
2.30	Farming systems	●													
2.40	Rice cultivation	●					●		●			●	●		
2.50	Rodent fauna			●					●		●				●
2.60	Large fauna														●
2.70	Bird fauna	●							●						
2.80	Aquatic fauna	●					●		●			●	●		●
3.00	Socio-cultural														
3.10	Susceptibility								●	●	●	●	●	●	
3.20	Social categories								●	●	●	●	●	●	
3.30	Customs	●								●			●		
3.40	Settlements	●					●		●	●			●		
3.50	Water contact						●						●		
3.60	Vector contact	●	●	●	●	●									●
4.00	Infrastructure	●					●			●			●		●
5.00	Disease management	●					●								●

8. IF there are seasonal food shortages THEN there may be a seasonal increase in susceptibility to infection.

9. IF a water resource is developed to increase agricultural production, THEN seasonal food shortages may be reduced.

10. IF there is increased contact with limited dry season water supplies THEN intense focal transmission of schistosomiasis may occur.

1.2 Temperature

1. IF the mean temperature is below 17° C THEN parasite development in the vector or intermediate host ceases (20° C for falciparum malaria, 14° C for schistosomiasis).

2. IF the temperature is very high THEN parasite development ceases AND the activity of vectors is reduced.

1.3 Wind

1. IF the project is in West Africa AND there are *Simulium* vectors breeding within 300 km upwind THEN recolonization of seasonal streams may be expected.

2. IF wind assists the drift of floatage THEN the dispersal of snail vectors may be increased.

3. IF the site is generally windy THEN biting activity will be greatly reduced.

4. IF there are exposed shores subject to wave action THEN the breeding of snails and mosquitoes will be greatly reduced.

1.4 Humidity

1. IF the humidity is very low THEN insects may be killed by desiccation OR they may seek shelter in relatively humid microclimates.

2. IF the development project is in an area of low humidity AND there will be a large scale increase in surface water THEN microclimate humidity will increase.

3. IF humidity is low THEN the survival of filarial parasites when they escape from the insects mouth parts may be reduced.

4. IF large scale changes in land use increase microclimate humidity THEN mosquitoes may live longer.

1.5 Rainfall

1. Rainfall correlates with malaria epidemics.

2. IF there is plenty of rainfall AND the soil is not too porous THEN temporary rainpools will be abundant.

3. IF the vectors breed in temporary rainpools THEN their breeding sites will be very difficult to control.

2. IF there is plenty of rain THEN water contact is reduced but snail breeding rates are increased.

4. IF rainfall is plentiful in the river basin AND hydrological conditions promote stream flow THEN stream margin breeding mosquito larvae will be flushed out but <u>Simulium</u> breeding sites may be enhanced.

5. IF hydrological conditions cause rapid alterations in stream depth THEN rock pool breeding sites will be created as the stream falls AND <u>Simulium</u> breeding sites may be created as the stream rises.

1.6 Topography

1. IF there is a steep slope THEN stream flow exposes bedrock (which provide breeding sites for various vectors).

2. IF there is a flood plain AND slowly meandering streams deposit silt THEN more permanent pools and marshes are created.

3. IF land is levelled for roads THEN borrow pits will be created.

4. IF borrow pits fill with water THEN mosquito and snail habitats are created.

5. IF there are fast currents AND an unstable stream bed THEN the site is unfavourable for snails.

6. IF bedrock is non-sedimentary THEN it is more suitable for <u>Simulium</u> breeding.

1.7 Soil type

1. IF soil is compacted OR ground cover is removed OR soil is exposed to excessively dry conditions THEN soil looses its permeability or porosity.

2. IF ground cover is removed THEN soil is eroded.

3. IF soil is eroded THEN shallow pools are created by silt deposition.

4. IF there are loess soils AND semi-arid conditions THEN rodent reservoirs of leishmaniasis may be abundant.

5. IF the soil is structurally poor THEN shallow latrine pits will collapse and provide vector breeding sites.

1.8 Water

1.8.1 Water Scarcity -

1. IF water is scarce OR supply is irregular THEN there will be domestic water storage (in which mosquitoes can breed).

2. IF there is a piped water supply AND inadequate waste water disposal THEN there will be muddy surrounding water (in which mosquitoes and snails breed).

3. IF water pipes leak THEN mosquito breeding sites are created.

1.8.2 Water Chemistry -

1. IF salinity is high THEN some species of mosquitoes are attracted AND other mosquito species are repelled.

2. IF surface water is subject to high evaporation rates THEN salinity increases.

3. IF a coastal site is occasionally inundated with seawater THEN saline pools are abundant.

4. IF nitrogen content is high THEN culicine mosquitoes may be more abundant than anophelines (exceptions include *Anopheles varuna* and *Anopheles annularis* in India).

5. IF insecticide spraying kills non-target organisms THEN algal blooms may stimulate vector production.

6. IF the calcium content is about 80ppm AND there is a balance of calcium, potassium and magnesium AND pH is slightly acid THEN snails may be abundant.

7. IF stream nutrient content and chemistry is suitable THEN simuliid vectors may be abundant.

8. IF there is a lake outflow AND algal blooms provide high nutrient levels THEN larvae of vector simuliids may be abundant at the outflow.

9. IF the water is turbid THEN important malaria vectors may be attracted but snails may be deterred (e.g., by puddling soils in rice fields).

1.8.3 Surface Water -

1. IF there is an abrupt margin between land and water THEN breeding sites are minimised.

2. If there is wave action AND a steep shore OR an unstable shore THEN mosquitoes and snails are deterred.

1.8.4 Canalisation -

1. IF canal linings are imperfect THEN seepage pools will provide important breeding foci.

2. IF rivers are crossed by fords, causeways or bridges THEN simuliid vectors may be provided with new breeding sites.

3. IF the project is in West Africa THEN crossing points may attract tsetse flies.

4. IF the mean flow rate is greater than 0.6 m/s AND the channel is free of vegetation THEN snails are deterred (but erosion of unlined channels may occur).

5. IF infective aquatic stages of schistosoma parasites are released in moving water THEN they may cause infection downstream.

6. IF fast flow rates are to be maintained THEN regular desilting, bank repair and clearance of aquatic weeds is necessary.

7. IF damage to canal banks is to be avoided THEN overpasses should be provided.

8. IF the water is relatively clean AND aerated AND flowing THEN simuliid vectors may breed. (Preferred habitats range from tiny streams and irrigation ditches to large rivers, to a depth of 0.15m. In W. Africa preferred flow rates are 0.7-1.2 m/s).

9. IF there are no local Simulium species breeding THEN seasonal migration of potentially infected Simulium may cause a hazard within 1.5km of the river bank.

10. IF channels are designed for rapid draw-down and adequate drying-out THEN pooling during periods of low flow rate may be avoided.

11. IF solid waste collection facilities are inadequate THEN drains will be blocked by domestic refuse.

12. IF water is channeled through numerous small ditches THEN maintenance is more difficult than for a few large canals.

13. IF an irrigation system contains night storage dams or canals THEN snail breeding should be expected (these habitats are difficult to treat with molluscicide).

14. IF night storage dams become infested with aquatic vegetation then Mansonia mosquitoes should be expected.

1.8.5 Water Collections -

1. IF there are numerous small collections of clean water (such as are found in discarded cans, tyres, containers, flower vases, ant-traps, leaf axils, tree holes, bamboo and rock pools) THEN Aedes mosquitoes may be abundant.

2. IF borrow pits result from construction activities AND fill with water THEN snails and mosquitoes may breed in them.

3. IF borrow pits are deliberately planned as water holes THEN they should be enclosed and/or treated.

1.8.6 Impoundments -

1. IF a reservoir floods a stream course THEN simuliid breeding sites may be destroyed but new breeding sites may be created at the spillway.

2. IF continuous discharge from a reservoir scours the stream bed THEN new breeding sites may be created downstream.

3. IF the water level of a reservoir can be varied THEN the breeding of vector mosquitoes and snails can be reduced (but fluctuating water levels favour some mosquito species).

4. IF land can be cleared before it is flooded THEN breeding sites may be much reduced (because there is more exposure to wave action).

5. IF complete land clearance is too costly THEN clearance should be restricted to the vicinity of human habitation or water margins (clearance should extend above the projected shore-line).

6. IF the water is deep THEN mosquitoes and snails will be deterred (they rarely occur in lakes and large ponds, except at shallow margins).

7. IF habitations adjacent to water margins are sited facing prevailing on-shore winds THEN wave action renders the margin unsuitable for breeding.

8. IF simuliids disrupt dam construction THEN larvicide should be applied upto 20km up- and down-stream during periods of rising and falling flood.

9. IF land is newly flooded THEN old mosquito breeding sites are flushed out but new breeding sites are eventually created (so mosquito abundance may initially fall before rising to new levels).

10. IF land is flooded THEN wild rodent populations are displaced and may be brought into closer contact with human communities.

11. IF the spillway is constructed of undressed stone THEN simuliid breeding is likely to happen.

12. IF the spillway is vertical OR overhung OR siphoned then simuliids are deterred.

13. IF the spillway flow is interrupted for at least 1 day in 7 THEN simuliids cannot breed on it.

1.8.7 Drainage and Sullage -

1. IF domestic water is supplied without adequate provision for waste water disposal THEN a major public health hazard is created.

2. IF an irrigation system has better maintained irrigation canals than drainage ditches THEN excess standing water creates a public health hazard.

3. IF water is moderately polluted THEN snail populations are favoured.

4. IF water is heavily polluted with human or animal faeces THEN culicine mosquitoes will be abundant.

5. IF an approved latrine design is used THEN mosquito breeding may be minimised (recommended designs include ventilated improved pit latrines, vault latrines and pour-flush latrines).

1.8.8 Ground Water -

1. IF the water table is close to the surface THEN latrine pits will fill with water and promote the breeding of culicine mosquitoes.

2. IF trees with high evapo-transpiration potential are planted THEN the level of the water table may be reduced.

3. IF the water table is very deep THEN vertical drainage may be used.

1.8.9 Irrigation Schemes -

1. IF molluscicide treatment is required THEN focal application can be very effective.

2. IF old irrigation ditches are filled and new ones constructed alongside THEN snail populations are eradicated (Oncomelanian snails were controlled in China by this method).

3. IF canals are lined THEN the recurrent cost of vegetation and erosion control is reduced.

4. IF water is piped THEN capital and recurrent costs are higher but health hazards are removed.

5. IF irrigation schemes are managed to provide the minimum of standing water for the minimum consecutive period THEN breeding can be controlled.

6. IF irrigation is intermittent AND soil infiltration rates are high THEN temporary pools persist less than one week.

7. IF temporary pools persist less than one week THEN malaria mosquitoes can not breed in them.

8. IF canals and night stores are drained in a 7 day rotation with 2 days dry THEN breeding is reduced.

9. IF an irrigation scheme is sited in a previously semi-arid region THEN health hazards are created because major ecological changes occur.

10. IF a scheme is surrounded by afferent canals THEN the invasion of rodent populations is reduced.

11. IF sprinkler or drip-feed irrigation is used THEN mosquitoes and snails are deterred.

12. IF in sprinkler and drip-feed irrigation systems the tube connections are not made leak-proof THEN mosquito breeding places will be created at these junctures.

2. BIOTIC

2.1 Vegetation on site

1. IF the banks of water courses are covered in vegetation THEN water flow rates are reduced and refuges provided for mosquitoes and snails.

2. IF water is shaded or partly shaded THEN some mosquito species will be attracted (e.g., *Anopheles minimus* and *Anopheles funestus*).

3. IF water is not shaded THEN some mosquito species will be attracted (e.g., *Anopheles gambiae*).

4. IF there is tropical rain forest vegetation AND shaded or partly shaded margins of forest pools and streams THEN malaria mosquitoes should be abundant.

5. IF tropical rain forest is unselectively felled THEN shade breeding species are eliminated (but soil erosion and loss of resources occurs).

6. IF tropical rain forest is selectively felled THEN disturbance of the ground creates additional breeding sites.

7. IF crop production simplifies the vegetation environment THEN more dangerous vector and snail species may be encouraged.

8. IF emergent or floating vegetation grows in deep water THEN vector breeding sites are created. (Mansonia mosquito larvae only breed in association with rooted or floating vegetation, especially Eichhornia, Pistia and Salvinia).

9. IF the vegetation provides natural water containers THEN mosquitoes will breed in them (e.g., bromeliads (including pineapple), bananas, bamboo, Colocacia and rotting tree stumps).

10. IF mosquitoes rest in vegetation near houses such as maize plants THEN removing the vegetation will not control mosquitoes because there are plenty of other resting sites.

11. IF there is halophytic vegetation THEN there may be reservoir hosts of leishmaniasis (e.g., the rodent Psammomys obesus).

2.2 Aquatic and terrestrial succession

1. IF land or water is cleared of vegetation during the construction process THEN an orderly process of vegetational succession (regrowth) will occur.

2. IF there is succession THEN vegetation will increase in size, density, cover and shade area (each phase in the succession will favour different species of animals, including vectors and their natural enemies).

3. IF there are dense stands of vegetation THEN there are relatively humid resting places which are favoured by vectors.

2.3 Farming systems

1. IF oxen are replaced by tractors THEN mosquitoes which were feeding on oxen may be forced to bite people (a resurgence of malaria in Guyana was attributed to this factor).

2. IF water buffaloes are replaced by tractors AND their traditional pools are drained THEN predator species of disease vectors may loose their dry season refuge and vector densities may rise.

3. IF agricultural insecticides are used on a large scale THEN vectors may develop resistance to a wide range of insecticides (e.g., Anopheles sinensis in China, Anopheles sacharovi in Turkey).

2.4 Rice cultivation

1. IF paddy rice has been transplanted AND is less than 75cm tall THEN malaria mosquitoes which prefer sunlit water will breed (e.g., *Anopheles arabiensis*, *Anopheles freeborni*, *Anopheles albimanus*).

2. IF the paddy rice is taller THEN shade loving malaria mosquitoes will breed (e.g., *Anopheles funestus*, *Anopheles umbrosus*, *Anopheles punctimaculata*).

3. IF human settlements are close to rice fields THEN high rates of mosquito-borne disease may occur.

4. IF insecticides are used to kill rice pests AND they kill aquatic predators THEN abundant mosquito breeding may result (e.g., use of Dimecron at Ahero in Kenya).

5. IF old plant debris is allowed to rot in newly flooded rice fields THEN mosquito breeding may be promoted (e.g., *Culex tritaeniorhynchus* in Sarawak).

6. IF rice is planted in trenches through which water flows THEN mosquito breeding may be prevented (e.g., *Anopheles pseudopunctipennis* in Mexico).

7. IF a belt of dryland crops is established around a village THEN people are protected from rice field breeding mosquitoes.

2.5 Rodent fauna

1. IF an irrigated scheme is being developed THEN rodent species which are closely associated with human settlements AND are potential disease reservoirs will increase in abundance (e.g., at Hola in Kenya abundance increased 10-50 times).

2. IF an irrigation project raises the water table THEN rodents such as gerbils may become less abundant but associated sandflies may become more abundant (e.g., a reservoir of dermal leishmaniasis which affected construction workers in Uzbekistan).

3. IF previously unpopulated areas are settled THEN increased human contact with wild fauna may promote zoonoses.

4. IF land is ploughed THEN burrowing rodents such as *Psammomys obesus* and *Rhombomys opimus* are eliminated but secondary vectors of leishmaniasis such as *Meriones* spp may become more abundant.

5. IF fodder crops are irrigated AND it is a semi-arid region THEN rodents may increase in abundance.

2.6 Large fauna

1. IF a settlement is planned AND the settlers keep domestic animals THEN hygienic animal pens should be included in the settlement design.

2.7 Bird fauna

1. IF wild birds are attracted to an irrigation project THEN there is a risk of arbovirus transmission such as Japanese encephalitis virus.

2.8 Aquatic fauna

1. IF certain fish are introduced into irrigation schemes THEN they can contribute to the control of vectors.

2. IF natural invertebrate predators such as dragonfly nymphs can be protected from insecticide THEN they will contribute to the control of vectors.

3. IF fisheries are drained or rotated periodically THEN schistosomiasis hazards may be reduced.

3. DEMOGRAPHIC, SOCIAL AND CULTURAL FACTORS

3.1 Susceptibility to infection

1. If the demographic characteristics of the population are known THEN potential disease problems can be forecast with greater precision.

2. IF a new settlement is developed THEN there will be more young fertile women and young children than in the rest of the population.

3. IF future settlers are screened for parasitic disease THEN the chances of introducing new strains of parasites can be reduced.

4. IF future settlers are screened on arrival, rather than at their place of origin, THEN anxiety, evasion and corruption may be reduced.

5. IF a large part of the population consists of children THEN schistosomiasis transmission is particularly favoured.

3.2 Social categories

1. IF there are large groups of construction workers THEN up to ten times as many spontaneous immigrants may be attracted informally to provide goods and services.

2. IF communities are displaced THEN they may be exposed to hazards with which they have had no prior experience.

3.3 Customs

1. IF rights to use a water source are traditionally vested in different interest groups THEN development of the water source may produce intergroup conflicts leading to the destruction of the project.

2. IF anal cleansing customs involve wiping AND a waste disposal system is designed which assumes washing THEN wiping materials may block the system.

3.4 Settlements

1. IF a community is displaced by a development project THEN disruption of social routines can be expected to last more than five years AND the community will be hostile to government AND local leaders will lose their legitimacy AND the community will be even more unwilling than usual to experiment with new technical possibilities OR commit their resources to untried innovations OR undergo massive re-ordering of social life (Colson, 1971).

2. IF domestic water is not disposed of properly THEN vector and snail breeding sites are created.

3. IF domestic water supply is unreliable THEN water will be stored and may provide mosquito breeding sites.

4. IF water sources are far from the home THEN water will be stored for longer periods.

5. IF there is inadequate provision for maintenance THEN piped water supplies and village pumps will be unreliable.

6. IF water supply and sanitation facilities are communal THEN there may be no incentive to maintain them properly.

7. IF there are septic pools OR surface grey water drainage OR poorly maintained latrines THEN the mosquito vector of lymphatic filariasis may flourish.

8. IF cultivation sites are far from permanent settlements THEN temporary settlements without proper sanitation will develop there.

9. IF water points are fitted with self-closing taps or handpumps THEN excess water discharge will be avoided.

10. IF houses are designed to prevent mosquito ingress THEN much potential disease transmission can be avoided.

11. IF house construction materials are absorbent THEN residual insecticide sprays will be less effective.

12. IF settlements are sited 2km from swamps and forest margins THEN they are outside the flight range of most mosquitoes.

13. IF there are locally breeding simuliids in a savannah or forest habitat THEN settlements should be sited at least 10km from the river.

14. IF a dry-crop zone is sited around a settlement THEN contact with vectors which breed in irrigated sites is reduced.

15. IF settlements are sited far from agricultural zones THEN watchmen will be required to deter theft.

3.5 Water contact

1. IF small children bathe in irrigation systems where there are snails THEN schistosomiasis transmission will be intense.

2. IF the climate is hot THEN the desire to bathe will outweigh any health education.

3. IF snail-free bathing areas are provided AND they are more convenient to use AND their use is promoted by health education THEN schistosomiasis transmission can be reduced.

4. IF bathing areas are sited in the centre of the village AND they are closer to the home than irrigation canals THEN they are more likely to be used.

5. IF bathing areas are to be kept free from snails THEN they should be refilled periodically and treated with molluscicide.

6. IF the use of water sources near settlements is deterred by fencing, culverts, bridges and steep-sided canals THEN water contact is reduced.

7. IF the daily cycle of water-related activities coincides with peak cercarial densities (the peaks are often during the middle of the day) THEN the risk of schistosomiasis infection is intensified.

8. IF the seasonal cycle of activity (such as farming or fishing) coincides with peaks of vector or cercerial density THEN the risk of disease transmission is intensified.

3.6 Vector contact

1. IF mosquito nets and screen are badly maintained THEN they are not effective.

2. IF the climate is hot, humid and windless THEN mosquito nets and screens are unbearable.

3. IF the farms are within 15km of a <u>Simulium</u> breeding site THEN farm workers will be bitten.

4. IF people are active indoors OR outdoors at sunset THEN they will be bitten by mosquitoes.

5. IF a vector is largely confined to feeding on animals AND it is not very abundant THEN it does not pose a major health hazard.

6. IF a biting insect cannot support the development of a parasite THEN it may be a nuisance but it is not a health hazard.

4. INFRASTRUCTURE

1. IF there is no coordination of water supply and sanitation THEN excess standing water and septic pools will promote disease transmission.

2. IF health care facilities are not upgraded in parallel with project development THEN they may not cope with the new demands which are imposed on them.

3. IF disease surveillance facilities are available THEN an early warning of vector-borne disease problems can be provided.

4. IF there is a hierarchy of health facilities THEN it should include district health workers and vector control workers at the village level.

5. IF village level preventive measures are to be effective THEN the community must be actively involved in their design and operation.

6. IF natural barriers are bridged THEN vectors and diseases are able to spread into new areas.

7. IF equipment and supplies for vector control are to be stored THEN adequate thief proof facilities must be provided.

8. IF health awareness is not promoted through education THEN no preventive measures are likely to succeed.

9. IF maintenance is to be effective THEN it must be envisaged at the design stage AND adequately budgeted AND appropriately organised AND properly carried out.

10. IF unusual methods of water supply and sanitation are used THEN effective maintenance is essential.

11. IF there is no system of solid waste disposal OR no adequate system of food storage THEN rodents, houseflies and cockroaches will multiply.

12. IF sanitation facilities are to be kept in good order THEN separate facilities will be required for each household.

13. IF schistosomiasis transmission is to be interrupted THEN urine and faeces should be prevented from entering irrigation or drainage systems.

14. IF refuse is tipped into water THEN breeding sites will be created.

15. IF refuse is used for sanitary landfill THEN surface water can be reduced.

16. IF there are health laws or ordinances which control conditions with the potential of promoting mosquito breeding AND an effective infrastructure for ensuring compliance THEN the community can be protected from the actions of the individual.

17. IF individual families OR small communities are to improve their standards of hygiene THEN a credit facility may be required.

18. IF economic activities depend on the production of vector breeding sites THEN control by legislation is impractical (e.g., coir rope workers in India and Sri Lanka must soak coconut husks in pits which breed filariasis vectors).

19. IF the control of breeding sites can be made into an economic activity THEN compliance is assured (e.g., aquatic vegetation in India is being harvested for paper production).

20. Economic activity may expose one human group to greater risks of infection (e.g., one sex may work in water).

21. IF engineering plans are countersigned by a public health official THEN public health interests may be protected.

5. DISEASE MANAGEMENT BY VECTOR CONTROL

1. IF a mosquito vector bites and rests outdoors THEN it can not be controlled by house spraying (have resting sites been checked recently?).

2. IF there is a house spraying campaign AND bedbugs are NOT controlled OR beneficial predators are killed OR the insecticide marks house furnishings THEN expect non-acceptance.

3. IF a vector is controlled by insecticides THEN sooner or later it will develop physiological or behavioural resistance.

4. IF insecticides are used to control agricultural pests THEN medical pests may develop resistance and biological control agents (such as larvivorous fish) may be killed.

5. IF molluscicide is applied to irrigation canals THEN it will be inactivated before it reaches drainage channels (within 24-36 hours).

6. IF biological control agents are used (parasites and predators) THEN periodic new releases will be required.

7. IF fish are used for vector control THEN fish-holding tanks should be incorporated in the project design.

CHAPTER 4. REFERENCES AND GLOSSARY

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Glossary

Anopheline = a mosquito of the subfamily which includes the genus Anopheles. May transmit malaria and other diseases.

Arboreal = in trees.

Arbovirus = arthropod borne virus.

Assessment = a process of choosing between alternatives.

Bilharzia = schistosomiasis

Bromeliad = A plant in the family which includes pineapples. They often have small collections of water at the base of the leaves.

Cercariae = The infective stage of the Schistosoma parasite, free living in water.

Culicine = a mosquito of the subfamily which includes the important genera Aedes, Culex and Mansonia. May transmit diseases but not malaria.

Endemicity

- endemic malaria = constant. measurable transmission and incidence of cases over consecutive years.
- hypoendemicity = little transmission, effect on the general population not important.
- mesoendemicity = the disease is found among small, rural communities in the sub-tropical zones with varying intensity depending on local circumstances.
- hyperendemicity = intense, seasonal transmission where the immunity is insufficient to prevent the effect of malaria on all age groups.
- holoendemicity = perennial transmission of a high degree resulting in a significant immune response in all age groups, but particularly in adults.

Endophagy = feeding indoors, opposite is exo-.

Endophily = resting indoors, opposite is exo-.

Environmental manipulation = making temporary changes to the environment with the objective of reducing vector abundance.

Environmental modification = making permanent changes to the environment with the objective of reducing vector abundance.

Epiphyte = a plant growing on the branches of trees, such as bromeliads in South-America.

Filariasis = A disease or infection caused by nematode worms which has several different forms.

Focus, plural foci = The origin(s) or source(s) of an infection or vector population.

Genus, plural genera = a category of biological classification comprising similar species; a rank between family and species.

Halophyte = A plant associated with saline environments.

Incidence = number of new cases of disease as a proportion of the population in a given period of time.

Intermediate host = the host occupied by juvenile stages of a parasite prior to the definitive host and in which asexual reproduction frequently occurs.

Larvivorous fish = fish species which feed preferentailly on mosquito larvae, thus contributing significantly to the reduction of vector densities.

Malaria = a disease of humans caused by blood parasites of the species Plasmodium falciparum, Plasmodium vivax, Plasmodium ovale or Plasmodium malariae and transmitted by anopheline mosquitoes.

Marsh potential = a measure of a water body's tendency to promote marshland.

Mitigate = to lessen the severity.

Molluscicide = A substance which kills molluscs such as snails.

Onchocerciasis = a disease caused by the parasitic filarial nematode Onchocerca volvulus, also known as "river blindness".

Parasite = an organism dependent upon another living organism to which it is detrimental.

Pathogen = an organism or substance which causes disease.

Phlebotomine = a group of biting flies commonly called sandflies including the genus Phlebotomus, sometimes vectors of leishmaniasis.

Prevalence = the proportion of a population infected by a pathogen at a given moment.

Refractory = resistant to ordinary treatment or infection.

Reservoir host = an animal species which carries a pathogen without detriment to itself and serves as a source of infection.

Safeguard = an activity intended to protect by preventing something from happening.

Simuliid = a family of biting flies commonly called blackflies including the important genus Simulium, sometimes vectors of Onchocerciasis.

Schistosomiasis = a disease caused by parasites of the genus Schistosoma, also known as bilharzia, which has an aquatic snail intermediate host.

Spp. = species (plural).

Succession = the process of ecological change in which a habitat is colonised by a sequence of animal and plant species.

Susceptible = prone to infection by parasites and pathogens.

Tabanid = a family of biting flies commonly called horseflies or deerflies, sometimes vectors of loiasis.

Tsetse = a biting fly found in Africa, genus Glossina, which may be a vector of sleeping sickness.

Trypanosomiasis = a disease caused by parasites of the genus Trypanosoma and including sleeping sickness (Africa) and Chagas' disease (Central and South America).

Vector = an organism which carries or transmits a pathogen.

Zoonosis = an infection of vertebrate animals transmissible to people.

APPENDIX 1

WORKSHEET 2. ANSWERS TO THE FLOWCHART QUESTIONS

PROJECT TITLE ______________________________

TYPE ______________________________

LOCATION ______________________________

PROJECT PHASE PRE-PROJECT/CONSTRUCTION/OPERATION

DISEASE ______________________________

COMPLETED BY:
NAME AND TITLE ______________________________

DATE ____________

A.0. THE DISEASE SITUATION

Is the disease prevalent?	DOES NOT OCCUR AT PRESENT RARE MODERATE HIGH
Are there any foci of drug resistance?	------------------------------ ------------------------------ ------------------------------
Could the project lead to increased disease prevalence? (See A.1.)	------------------------------ ------------------------------ ------------------------------

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A.1. Could the number of susceptible and infectious people change, as a result of the project? (see A.2.1.)	------------------------------ ------------------------------ ------------------------------ ------------------------------
Could wild animals provide a source of infection, in other words is there a disease reservoir in animals?	------------------------------ ------------------------------ ------------------------------ ------------------------------
Will wild animal populations be affected by the project? (See A.2.2.)	------------------------------ ------------------------------

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A.2.1. What human groups will be associated with the project? What size is each group? What is the origin of each group?	------------------------------ ------------------------------ ------------------------------ ------------------------------ ------------------------------

A.2.1. (continued)

Which groups are susceptible to this disease?

Is health status of any group expected to change, leading to change in disease susceptibility?

A.2.2. What animal species are the disease reservoirs?

Are the animal species that serve as a reservoir found near the project?

Will they be introduced to or attracted by the project?

Can introduction be prevented?

Can the disease reservoir be eradicated?

Will the animal population increase as a result of the project?

B. THE DISEASE ENVIRONMENT

How is the pathogen usually transmitted?

Which vector species are important in the region?

Are the species abundant at least seasonally or in discrete foci?

How will the transmission pathway be affected by the project?
(See B.1.)

B.1. Will vector abundance be affected by the project?
(See B.2.1.)

Will vector or water contact be affected by the project?
(See B.2.2.)

B.2.1. Are the vectors abundant on similiar projects in the region?	
Will the availability of vector breeding sites be increased? (See B.3.1.)	
Will vectors colonise the site from elsewhere? (See B.3.2.)	
B.2.2. Does vector behaviour favour man-vector contact? (See B.3.3.)	
Does human behaviour favour man-vector or man-water contact? (See B.3.4.)	
B.3.1. What are the preferred breeding sites of the vector?	
Which species favours which class of breeding site?	
Are breeding sites abundant, or present in restricted foci? Are they permanent or seasonal?	
What features of the geophysical environment favour the breeding sites?	
What human activities could affect the abundance of breeding sites?	
Will the project create additional classes of breeding sites?	
B.3.2. Is the vector species abundant upwind or upstream during a favourable season?	
Do climatic conditions favour long distance migration?	
Is passive migration by vehicle or livestock possible and likely?	
B.3.3. Do the vector species associate with human communities?	

B.3.3. (continued) Do the vectors inhabit rural or undisturbed environments?	----------
Will the project affect vector behaviour?	----------
B.3.4. Do human groups venture into rural or undisturbed habitats where there is a risk of disease transmission? For what purpose?	----------
Do activities at project site provide special opportunities for vector or water contact?	----------
Will project change human activities?	----------
Will change in human settlement density affect vector or water contact?	----------

C.0. THE DISEASE MANAGEMENT PRACTICES

Are there effective preventative measures for the disease? (See C.1.1.)	----------
Is there effective local medical care for the disease? (See C.1.2.)	----------
Can district health services cope with additional workloads created by the project?	----------
C.1.1. Is there effective, routine control of vectors in the region? (See C.2.1.)	----------
Have vector control measures been incorporated in the project design or operating schedule? (See C.2.2.)	----------

C.1.2. Do prophylactic drugs exist and are they used effectively?	
Are treatment facilities accessible?	
Geographically	
Economically	
Culturally	
Can the disease be effectively treated?	
Are medical facilities incorporated in project design?	
Can the disease be identified locally?	
C.2.1. Are the animal disease reservoirs controlled or controllable?	
Is there effective pesticide application?	
Is there effective vector population monitoring?	

C.2.2. Do any features of the design help to prevent vector breeding?	
Do any features of the operating schedule ensure periodic breeding site destruction?	
Can project design be modified to prevent vector breeding?	
Can human contact with vectors or unsafe water be prevented?	

APPENDIX 2

Checklist of questions to be asked at the ministry of health, at the district health centre and at other government departments. Questions are cross-referenced to the flowcharts.

Ministry of health, district health team and specialist units

A.0. Which vector-borne diseases occur in this region? Is there an entomologist or pest control officer who can be contacted? Is there a game or animal control officer who can be contacted?

A.0. How prevalent is each disease? Is project likely to lead to increase of disease and why? Are there any foci of drug resistance? Is the causative agent of the disease locally resistant to drug therapy?

A.2.1. For each human group affected by the project, are they likely to be susceptible or immune to the disease? Is the health status of each group likely to lead to a change in susceptibility?

A.2.2. Is there an animal disease reservoir?

C.0. Are there effective preventative measures? Can the disease be effectively diagnosed and treated under local conditions? Can district services cope with the additional workloads created by the project? Are there sufficient supplies of drugs and equipment? Are prophylactic drugs available?

C.1.2. Are treatment facilities accessible to local people? Are prophylactic drugs used effectively by most of the people? Are susceptible human groups protected from infection?

Game or animal control officer or department

A.2.2. Is there an animal disease reservoir at or near the project site? What species? Have the animal reservoir species been attracted to similar projects? Can the animal reservoir be controlled or eradicated? Will project increase the size of the reservoir population?

Entomologist, vector control department or pest control officer

B.0. Which vector or host species is usually involved with this disease? Are these vectors or hosts known to be present at or near project site, at least seasonally or in discrete foci?

B.3.1. What are the preferred breeding sites of locally important vector and host species? Which species is associated with each category of site? Are breeding sites abundant permanently or seasonally? Which season? Will the project create additional classes of breeding sites?

B.3.2. Are the vectors abundant upwind or upstream of the site? How far away? Is long distance migration of the vector expected? Is passive migration by vehicles or livestock expected?

B.3.3. Do the vectors inhabit undisturbed rural environments? Is there a control programme against the vector population in the project area? Is the project likely to change vector behaviour?

B.3.4. Can contact between people and the vector be reduced or avoided?

C.0. Is the vector control programme effective?

C.2.1. Is there effective local pesticide application?

Project planners

A.2.1. What is the size of each human group associated with the project?

A.2.2. Can design be changed to prevent introduction of animal reservoir?

C.1.2. Are medical care facilities incorporated in project design?

B.3.4. Will people venture into rural habitats in which there is a risk of disease transmission? Will project change human activities and settlement density?

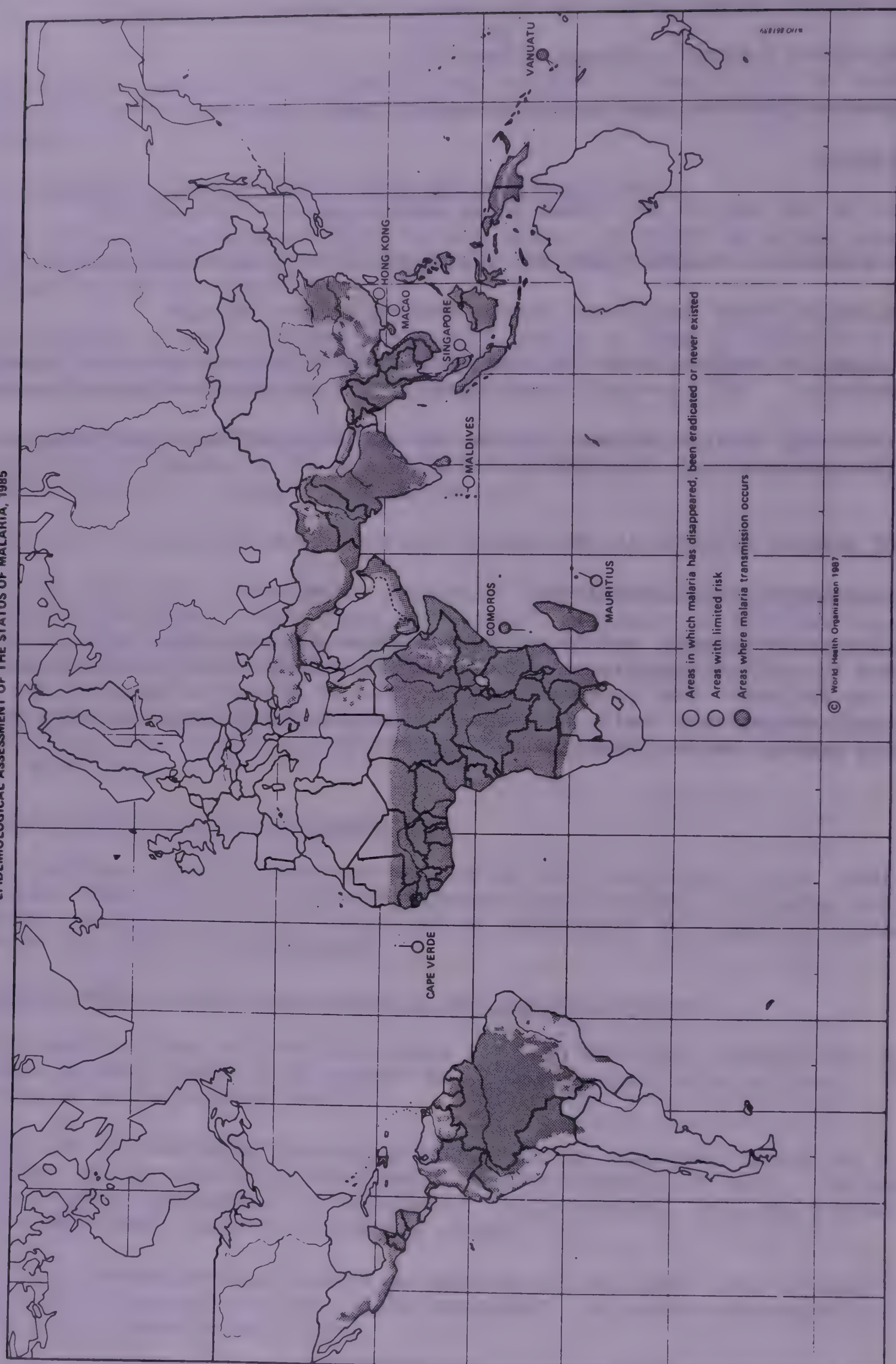
Are there any similar projects in the region? Which officers are responsible for the management of these other projects?

Managers of similar projects in the region

(Various sections of the flowcharts)

What reservoir animals, vector and host species are associated with the project? How are the medical pests controlled? What disease problems are associated with the project? What preventative, curative or mitigation measures are required, and at what cost? What features of the design or operating schedule help to prevent vector breeding?

EPIDEMIOLOGICAL ASSESSMENT OF THE STATUS OF MALARIA, 1985

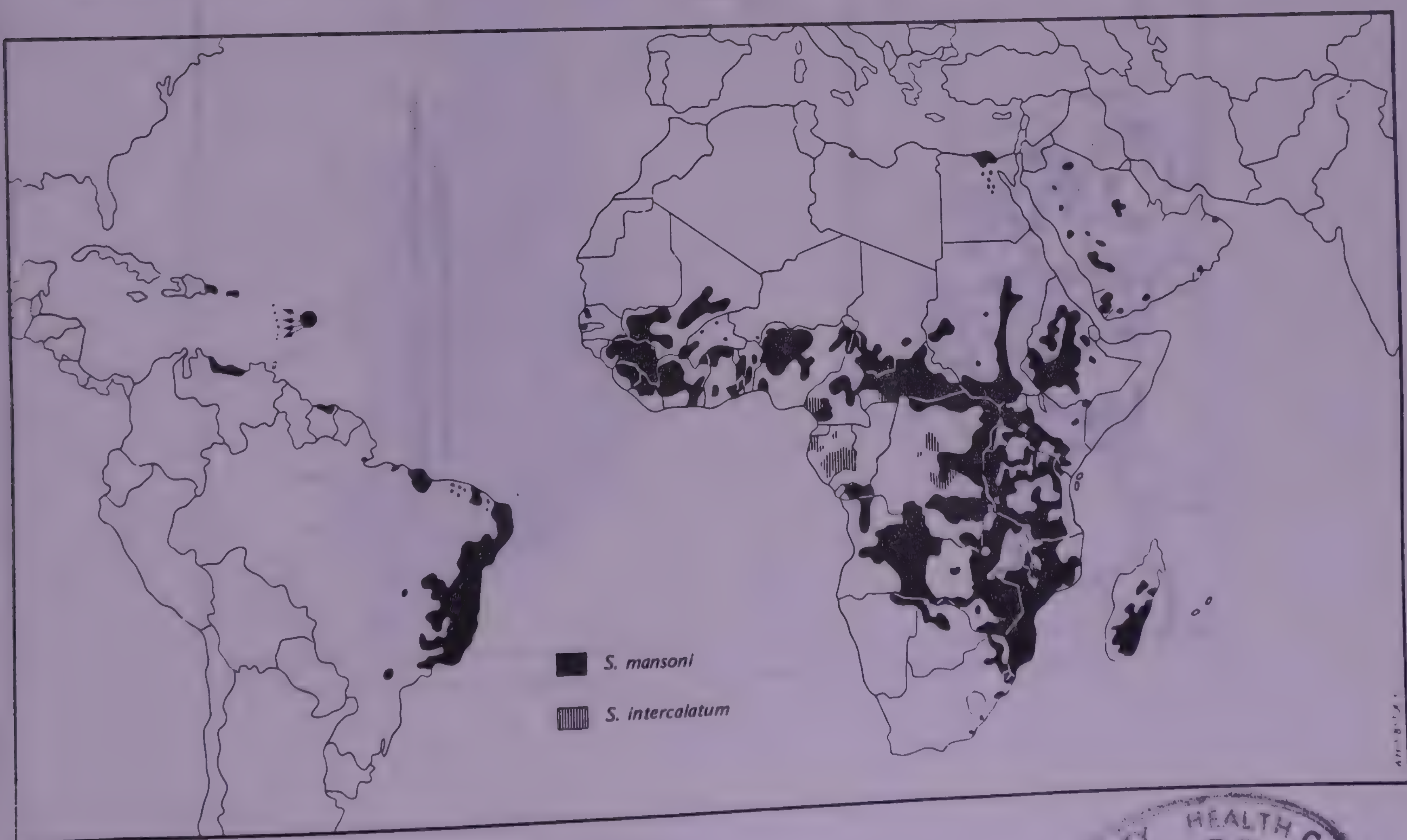


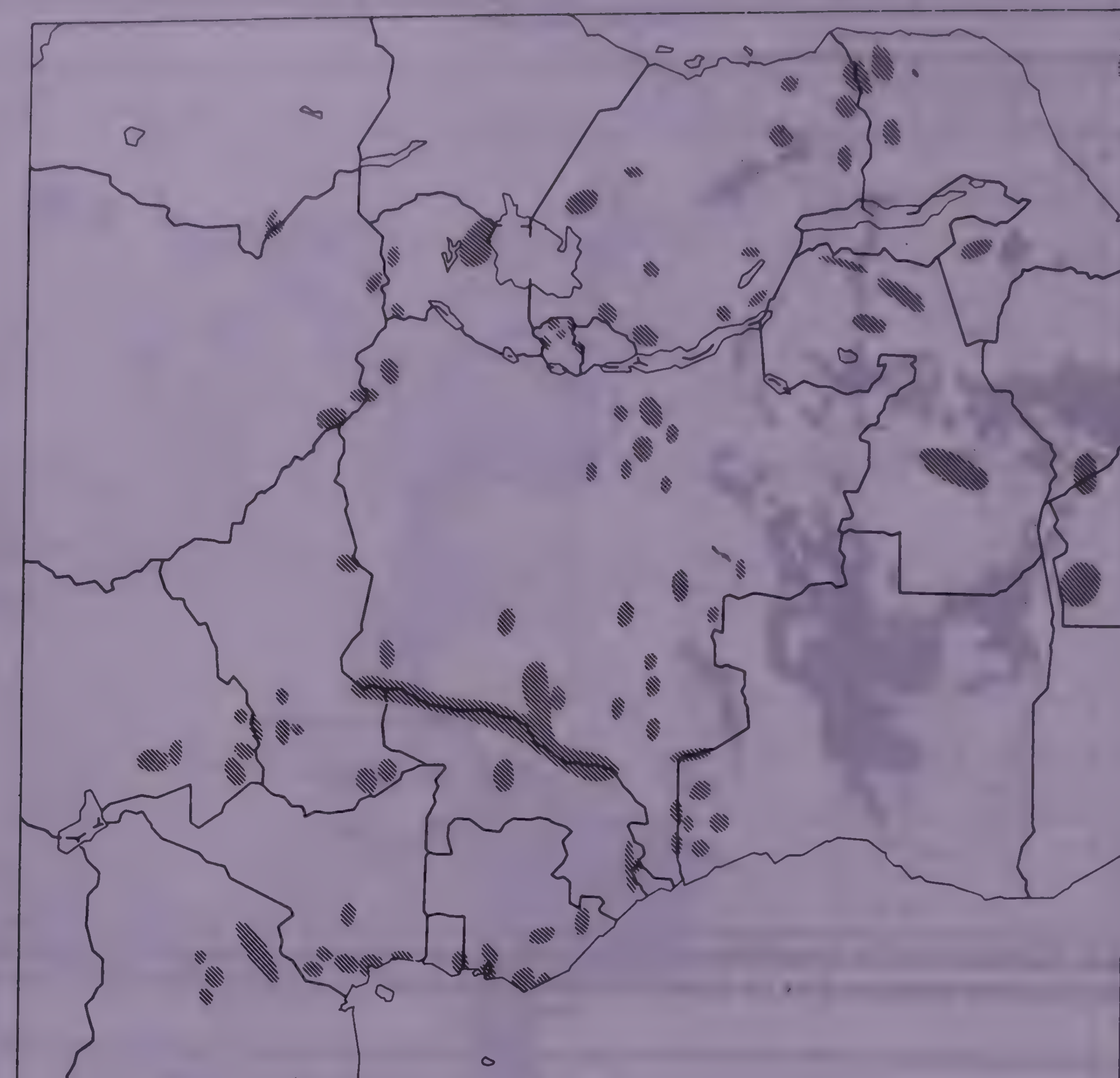
MAP 1. GLOBAL DISTRIBUTION OF SCHISTOSOMIASIS DUE TO *SCHISTOSOMA HAEMATOBIUM* AND *S. JAPONICUM*, 1983

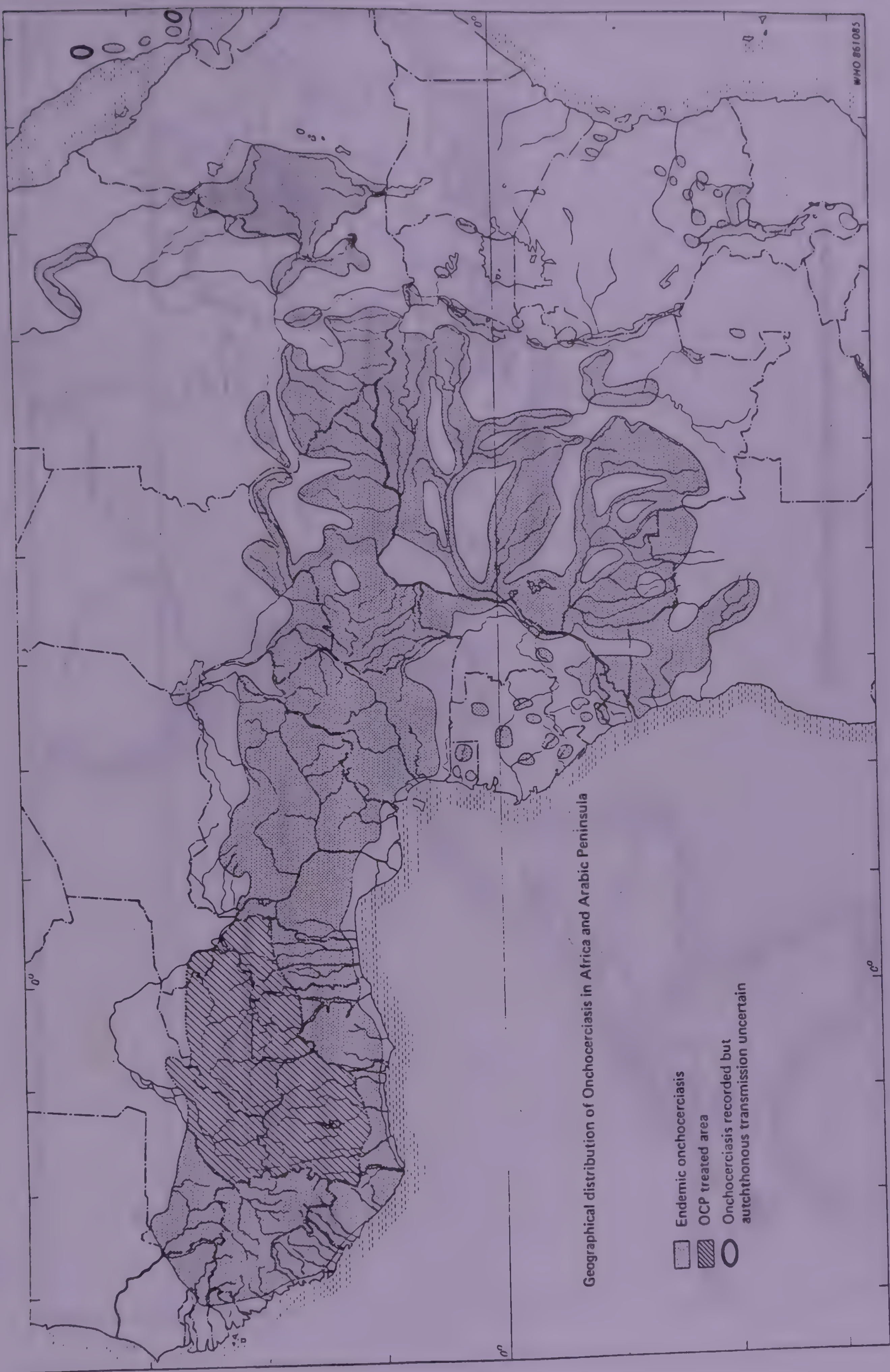
CARTE 1. DISTRIBUTION MONDIALE DE LA SCHISTOSOMIASE DUE A *SCHISTOSOMA HAEMATOBIUM* ET *S. JAPONICUM*, 1983

MAP 2. GLOBAL DISTRIBUTION OF SCHISTOSOMIASIS DUE TO *SCHISTOSOMA MANSONI* AND *S. INTERCALATUM*, 1983

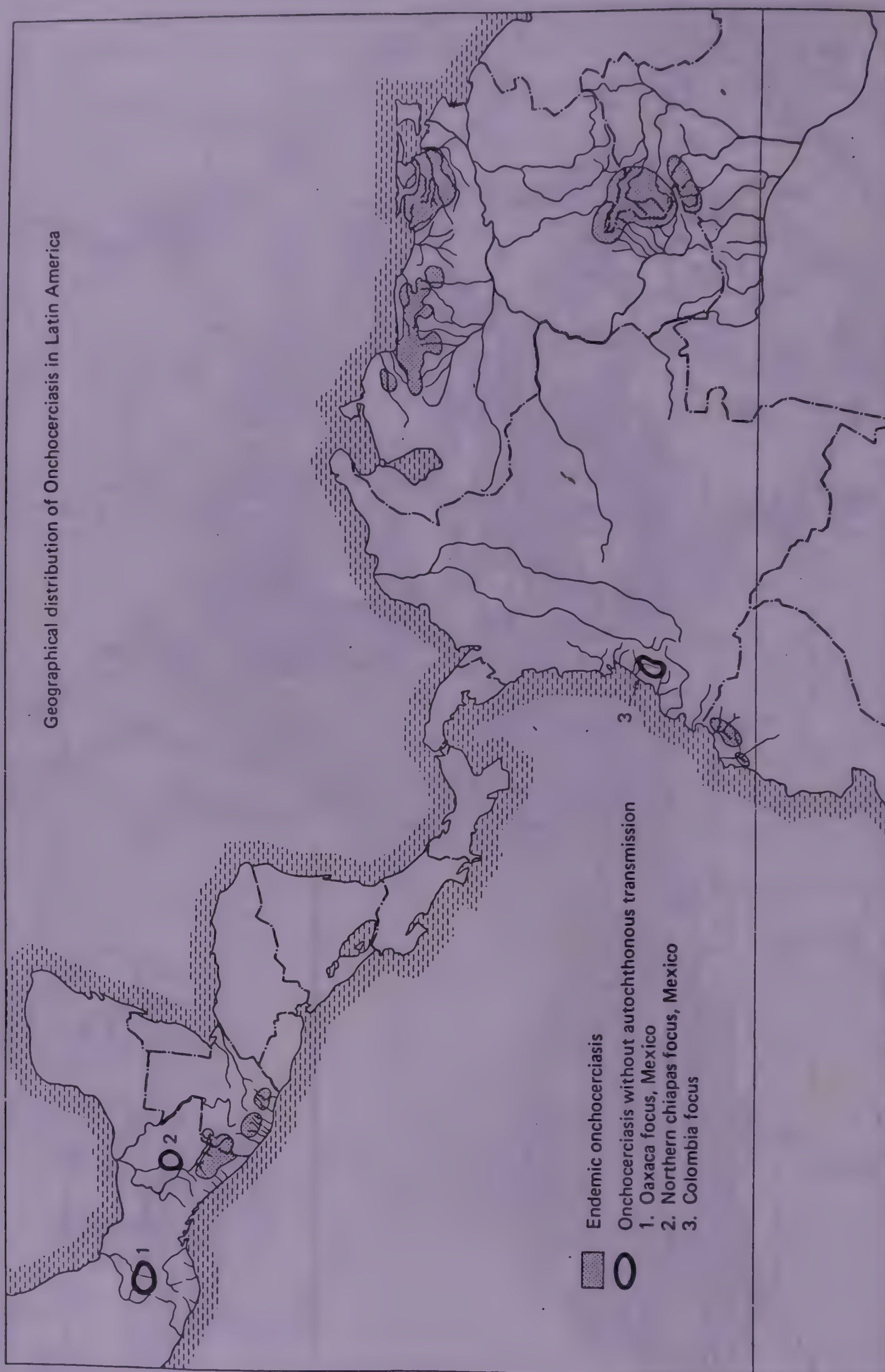
CARTE 2. DISTRIBUTION MONDIALE DE LA SCHISTOSOMIASE DUE A *SCHISTOSOMA MANSONI* ET *S. INTERCALATUM*, 1983




PRINCIPAL FOCI OF SLEEPING SICKNESS
PRINCIPAUX FOYERS DE LA MALADIE DU SOMMEIL



Geographical distribution of Onchocerciasis in Africa and Arabic Peninsula


Geographical distribution of Onchocerciasis in Latin America
Endemic onchocerciasis
Onchocerciasis without autochthonous transmission
1. Oaxaca focus, Mexico
2. Northern chiapas focus, Mexico
3. Colombia focus
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NOTES AND PERSONAL OBSERVATIONS

NOTES AND PERSONAL OBSERVATIONS